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KANSAS CITY

REVIEW OF SCIENCE AND INDUSTRY,

A MONTHLY RECORD OF PROGRESS IN

SCIENCE, MECHANIC ARTS AND LITERATURE.

VOL. VIII. JANUARY, 1885. NO. 9.

GEOLOGY.

THE LAST SUBMERSION AND EMERGENCE OF SOUTH-EASTERN KANSAS FROM THE CARBONIFEROUS SEAS, OR THOSE EFFECTING THE CARBONIFEROUS FORMATION IN KANSAS.[1]

E. P. WEST.

The country along the line of the Southern Kansas Railway, all through southeastern Kansas and extending westward to Harper, the present terminus of the road, is unsurpassed in beauty and the fertility of its broad fields and valleys. It is said, and truthfully, to be the paradise of the husbandman and stockman, and it is no less so of the geologist, the poet, and the artist.

Whoever has traveled over the line of this road cannot have failed to observe the picturesque and poetic beauty everywhere meeting the eye. Symmetrical mounds rise from the broad plains and valleys, as if by the work of magic, and terraced cliffs, terrace rising above terrace in solemn grandeur, environ the road. Sometimes the cliffs are circular, forming vast amphitheatres extending back for miles. These mark the last emergence of southeastern Kansas from the carboniferous seas, and bear unmistakable evidence of powerful and persistent forces which, though perhaps, comparatively brief, have left their impress boldly written on every feature of the country.

1 Read at the Annual Meeting of the Kansas Academy of Science, November, 1884.

Water-worn pebbles, commonly known as gravel beds, are found in the channels of streams, in the valleys under the soil, and over the highest mounds and ridges, all over the country. They are encountered north of Ottawa, and extend southward into the Indian Territory, westward to beyond Burlington, and eastward into the State of Missouri. How much beyond the limits indicated they extend I am unable to say, but it is probable that their range is much wider. This, however, can only be determined by an exploration of the adjacent country. Independent of their scientific significance, these beds are important in an economic point of view, affording free underdrainage and supplying good and convenient material for road-making. Along the bases of mounds and cliffs, and often for a considerable distance removed from them, as well as on the tops of the highest ridges and mounds, at and near the surface, the rocks often stand vertically to the plane of stratification, or inclined at various degrees from this tine. This is notably conspicuous in many places.

Not unfrequently old landslides are to be seen projecting from the mounds, or the brink of cliffs and extending out for hundreds of feet. Indeed, the whole country wears the appearance of having once formed the bed of shallow seas, divided into numerous channels of various widths, some of the cliffs during the recession of the waters perhaps forming coast lines while the higher lands may have been low islands. Such is the condition of things conspicuously marked over the entire area named.

To what cause is this grand work to be attributed? It could not have been done by rivers, for the pebbles, though water-worn, are too widely distributed for the work of the broadest of such streams. It was not effected by glaciers, for the vast land-slides, the conformation of the mounds and cliffs, the vertical position of the rocks, where the stratification has been disturbed, the absence of erratic rocks, and the lack of the commingling of the local rocks, all preclude this idea. If it had been caused by glacial action there would have been an intermingling of all the rocks torn down, indifferently. This, however, is not the case anywhere in the district observed. Neither are the beds composed of altered drift, for if they were so they would be homogeneous in their general distribution; but this is not found to be the case, for in some localities they are composed of chert alone, while in others they contain small broken fragments of sand-rock alone, in each instance identical with the adjacent local rocks. No erratic, trap, or igneous rocks, or limestone is anywhere to be found intermingled in the beds. The absence of trap and igneous rocks is accounted for from the fact that the glaciers did not extend so far south. The absence of limestone, though the prevailing local rock of the country, will be explained further on. It was not caused by volcanic action, upheavals, or folding of strata, for the under strata rest undisturbed.

Though evidently not caused by any of these agencies, the mounds, the terraces, the cliffs and the water-worn pebbles, and broad plains and valleys, are conspicuous, grand, and picturesque, facts which stand out in bold relief in the entire district, and prove a wide-spread destruction of its former surface. The

whole country, indeed, has been denuded for, at least, from fifty to two hundred feet in vertical thickness, leaving the more impregnable mounds and cliffs, the pebble beds, and broad plains and valleys, standing monuments to bear witness to the general destruction which, in a past age, took place. The power which caused it must have been great and persistent, and can only be determined by the evidence it has itself left impressed on the field of its operations, and which if correctly read, will, unerringly, lead to its detection. This reading points clearly and unmistakably to water aggregated in broad and shallow seas as the author of the stupendous work. The deposits of pebbles, clays, and soils, the great landslides, the mounds, cliffs, and terraces, and the inclination of the disturbed rocks, marking the country so persistently and conspicuously, could have been caused in no other way.

These seas were, no doubt, connected with an ocean, or deeper and more extended waters, lying to the southward and westward; but at what era of geological time is somewhat uncertain, except that we know it must have occurred since the carboniferous age, for the upper coal measures and Permian rocks are those destroyed.

Co-extensive with this area of devastation, as far as I have had an opportunity to examine it, and, I presume, co-extensive with its entire limits, there is scattered over the country, resting upon the surface or buried under the recent alluvial deposits, silicified wood which grew at a time intermediate between the carboniferous vegetation and our recent forests. The carboniferous wood is invariably imbedded in the stratified rocks, while this intermediate wood is invariably upon the surface, as resting under recent alluvial, or vegetable deposits. This would indicate that portions of Kansas, at least, were covered with forests at the time this widespread destruction began, and subsequent to the carboniferous age, portions of which must have been swept away and destroyed by the submergence of the country, while other portions of it, where the conditions were favorable, were silicified in the mineral waters of the seas and left scattered over the old sea-bed, in positions at or near where it is now found, when the land for the last time, in southeastern Kansas, emerged from the water.

The petrified remains of this intermediate forest, when its limits are fully known, may give some clue to the time of this era of denudation. To the westward, in the region of middle Kansas, the bones of species of animals now living, and the remains of man, have been found buried under alluvial deposits of wide occurrence, and at considerable depth below the surface. If the intermediate fossil wood should be found, as it probably will be, associated with these buried remains, it will render the probability great that this era of waste was comparatively recent, and that man may have reposed under the shade of the forests which preceded it, and which were involved in its devastations. But there is an equal probability that it may have occurred at an earlier date of the world's history.

This last era of submersion in Kansas seems to have been one of destruction, for no fossil remains of sea-life seem to have been left to indicate the age of

its occurrence, and to determine this, resort must be had to preceding life, or to synchronous air-breathing animals which may have been carried out by ocean currents and buried under their deposits.

The absence of life, or the fossil remains of life of this era are not to be wondered at when we consider the wide-spread destruction which took place in it. All of the lime rocks which were torn from their beds were destroyed, utterly, either by the chemical action of the acids in the water, or ground up by the attrition caused by waves and currents, or, most probably, by both of those causes combined, and carried away, in part, to distant and deeper waters, and in part left to form the soils of the local valleys. The more enduring silica was rounded by the action of the water and left in the beds so widely distributed over the country.

Where the destroyed strata were composed of limestone alone, no pebbles are be found, but where the lime rocks contained masses of chert, or where the strata were composed of chert entirely, the pebbles are found, and the beds vary in thickness in proportion to the amount of material torn down. Where the destroyed strata are in a locality of sand rock, and composed of sand rock alone, the gravel beds are composed of their fragments alone. There may have been, and undoubtedly there was, some drifting together of the pebbles, caused by the waves and currents of the sea, but in the main they are confined to the locality where they were torn down, and are nowhere of any considerable thickness.

There are now in the museum of the University of Kansas perhaps a hundred specimens of fossil shells collected from these beds at various and widely separated localities, identical with the undisturbed fossils of the respective localities where they were found, and which prove conclusively, if additional proof were needed, that the pebbles composing these beds are but the more enduring parts, or silica, entering into the composition of the local rocks destroyed. The silica, being impervious to the acids which aided the destruction of the lime rocks, remains imbedded where showered down from the general ruin, and as left when the land emerged from the water except where the beds have been since locally altered, to a limited extent, by rivers and other streams of water cutting through them.

I am aware that erosion, and changes in the elevation of land of continental extent occurred during Post Tertiary time; but it is not probable that all the changes happened at the same time, and we must look to the respective changed localities, to determine the relative ages when this work was done. In this paper I have considered southeastern Kansas only, and have attempted to sketch the condition of things wrought out by natural forces in it.

NOTE.—This subject will be continued in the next number of the REVIEW.

PRACTICAL STUDIES IN GEOLOGY.[1]

CHAS. H. STERNBERG.

Geology is a world study, and takes the earth as soon as it was cool enough to allow the atmosphere to disgorge its contents on the steaming earth.

Then began the operation of natural laws, and the causes and effects, as we see them to-day. The rain fell in torrents on the steaming earth, and washed away the solid rocks, and in shape of clay or sand the streams carried it to lower levels and deposited it on the bottom of the sea, as sedimentary rocks. The study of geology is the grandest of the natural sciences, not only because it takes into consideration the largest object with which we have to do, but it includes vast lapses of time, so long in fact that if it does not prove that time is eternal, it shows it least that it is very old. The text-books of the geological student are the solid rocks in which the Creator has written in never fading characters the history of each succeeding period, its life, climate, depth of sea, etc. All the natural sciences bring from their store-houses things new and old to increase its interest. If we go to the sea-shore, and notice the shells lying on the beach which an incoming wave covers with sand, or mud, we see the process by which fossils are made. The sea may come in and by pressure convert the sand, or mud, into solid rock, and the shells will be indefinitely preserved, and they represent existing species.

If we notice the accumulations at the mouths of great rivers, like the Mississippi, we find, mingled with the sand, or mud, trunks of trees, bones of animals, etc., that have been drifted from the far interior, a thousand miles perhaps. These are mingled with shells and sea-weed from the sea-shore, and represent the life of a continent. The sand and mud may, by pressure, be converted into rock, and the relics be preserved for ages. Petrifaction will take place. This is a slow process: as the contents of the organic cells decay they are carried away by water, which holds silica in solution; this is deposited in the empty cells, making a perfect cast, and so cell after cell is built up of silica. This as I said is a very slow process. In Pliocene time the bones are but partially petrified, while only in the older formations are they completely silicified. Another way nature has of preserving her records is by making casts of shells, leaves, sea-weeds, etc.; a leaf falling in the soft mud is covered up, and a perfect cast made of both sides. In some formations the lime of shells has been entirely carried off, and only casts remain. If we go to Florida we will see the process of rock making. Shells are mingled with the remains of others that the waves have ground to powder, which acts as a cement binding the shells together, strong enough to use for building material.

If we go into the hills and find in the solid limestone shells, sea-weeds, etc.,

1 Read before the Kansas Academy of Science, November, 1884.

we can but acknowledge that they represent the life of the period, when as soft mud, this limestone was lying in the bottom of the ocean. And so by natural causes have all the geological records been kept. Many people suppose that the study of geology is dry and stupid, of old bones and rocks. But there is no wider field for the imagination than to people the old seas and lands with animals restored from their buried relics, to clothe the ancient lands with verdure, and map out the continents, study their physical geography, the depth of the sea, climate, and above all to study the introduction and succession of life on the globe and other manifold changes brought about in the animal creation, their development from lowly forms, and their progression through successive changes, until the present state of perfection has been brought about. Life is too short to study the changes brought about by the lapse of countless ages. Mountains have been elevated, valleys hewn out, chasms drilled through the hearts of mountains and many other grand phenomena. The early geologists divided the world's history into distinct periods, supposing that at stated times whole genera were swept from the face of the earth, and new ones created.

These periods have been divided into *Palæozoic* or ancient life; *Mesozoic* or middle life, and *Cenozoic* or recent life. The first period in *Palæozoic* time is the *Silurian* or age of mollusks, and the enormous belts of limestone laid down attest to the abundant shell-life of the period. This was followed by the *Devonian* or age of fishes. They were all cartilaginous, and but few of their remains are preserved, the *Lepidosteus*, resembling our common gar-pike, then appeared, as well as sharks and rays. The last period in *Palæozoic* time is the carboniferous or age of coal plants. The air was dense with carbonic acid, and the luxuriant plant-life cleared the air of this poisonous gas, and stored it away in the great coal fields. Among the plants were the *Sigillaria*, *Tree Fern*, *Horse-tail*, *Cycads*, etc. The ground, and fallen wood, was covered with sponge-moss. At times the sea came in and covered the organic mass with sand, or mud. The rulers of the estuaries were great placoderms. They were clad in armour of bony plates, resembling shields and bucklers. Sharks and rays, with huge frog-like batrachians, were abundant. At the close of *Palæozoic* time *Cenozoic*, the age of reptiles, began. The first period is called Jurrassic, from the Jura Mountains. Here both on land and sea, enormous reptiles reigned supreme, and America has furnished some world-renowned monsters. In the Rocky Mountains, for a number of years, large bones have been found. People supposed them to be fragments of fossil wood.

In 1877 Professors Marsh and Cope made important discoveries, and published the results of their labors, thus adding another chapter to American palæontology. These were the largest known land animals and are called Dinosaurs. The larger ones reached a height of twenty-five feet and sixty feet in length. They were plant-eaters and fed on the leaves and tender branches of the luxuriant forests through which they wandered. The carnivores or flesh-eaters were smaller and more elegantly built for springing on the clumsy herbivores. They had on each jaw a single row of recurved, serrated teeth. The plant-eaters had several

rows. In the Judith River group the *Dinosaurs* walked erect; their front limbs were small, and armed with claws for grasping the branches of trees on which they fed. A ponderous tail helped to support their enormous weight. They had three rows of teeth in each jaw, with a magazine below each old tooth, containing five young ones. As fast as one row wore off another took its place. We found thousands of these cast-off crowns. The second period is called the Triassic. Here huge reptiles on sea and land were the ruling types. Some are called Labyrinthodonts from the peculiar manner in which the enamel of the teeth is folded. They were clad in armors of bony plates. Crocodile-like animals, with beautifully sculptured bones were common, as well as sharks, gars, etc.

In northern Texas the beds are made up chiefly of red clay, which is so finely divided that all the waters flowing from them, hold it in solution. During high water or on windy days, the water is as thick as cream. The next period is the Cretacous when the chalk of England and America was laid down. The first group in the west is called Dakota, by Prof. Hayden. The formation of red-sandstone, and variegated clays, were laid down in an open sea dotted here and there with islands. The formation enters Kansas near the mouth of Cow Creek, extending in a northeasterly direction through the State, Nebraska, Minnesota, British America and so on to Greenland. The trees, like those in our existing forests, then appeared. Here flourished the magnificent Red-wood, *Catalpa*, *Menispermites*, Tulip-tree, Cinnamon, Fig, *Sassafras*, etc. They left impressions in the sandstone of Kansas and Nebraska, and some two hundred species have been described by the noted palæontologist Prof. E. Lesquereux, of Columbus, Ohio.

During the Niobrara group great beds of chalk and blue shale, were laid down in western Kansas. Here appeared the first bony and edible fishes: *Portheus Molossus*, Cope, reached a length of twenty feet. It had a large bull-dog-shaped head with fangs projecting four inches from the mouth. It had another weapon of offense and defense in the shape of pectoral and dorsal fins, three feet long. In some species, one edge is serrated, and even in their fossil form are hard enough to be used for splitting wood. Another peculiar species was Cope's *Erysicthes* or snout fish. It used this weapon as a modern sword-fish does its sword. But the rulers of the deep open sea were the Saurians or sea-serpents. Cope's *Liodon poriges* reached a length of eighty feet. It had four powerful paddles, which by the aid of a long eel-like tail enabled it to go through the water at great speed. Its weapon of offense was a long bony snout, that was used as a battering-ram.

Clidastes tortor, Cope, was a small animal, about forty feet in length. It was provided with an additional set of articulations in the vertebræ to enable it to coil up, like a snake. Marsh's *Clidastes pumulus* was only twelve feet long, and doubtless often fell a victim to the sharks and other rapacious fishes that abounded in these waters. One peculiarity of these Saurians was that they had no expansible gullet, as in modern serpents; another method was given them in the shape of hinges of the ball and socket pattern just back of the dentry-bone. This en-

abled them to expand the cavity of the mouth and swallow large morsels, through a pelican-like throat.

The most interesting fossils found in the rich beds of western Kansas are Marsh's toothed birds. His *Hesperornis regalis* reached a height of nearly six feet. The wings were not developed. They were swimmers and lived on fishes. They were provided with a row in each jaw of sharp, reptile-like teeth, and thus nearly approach them. Many suppose that they were derived from reptiles; another proof is in the oldest of all birds, that had a long vertebrate tail; and the most important discovery in this line was made by Prof. Marsh this year in the Rocky Mountains, having found a small Dinosaur that walked. The metatarsals and carpals were united, as in all modern birds.

Great flying dragons, or *Pterodactyls*, were common, with stretch of wings of twenty-five feet. They were toothless and Marsh has made the new genus *Pteranodont* for them. Another very unique species was Cope's *Protostega gigas*. It measured twenty feet from one flipper to the other, and instead of the ribs being expanded and united, as in modern turtles to form a shell, they were separate. Instead of a shell, they were provided with great dermal plates, an inch thick in the centre, two feet in diameter and beveled off to a thin figured margin. One specimen found by my party in 1877 weighed 300 pounds after the matrix was removed. It was eighteen inches from one condyle of the lower jaw to the other. Great oyster-like shells, twenty-seven inches in diameter, were found. But we must leave this interesting group to go on to Cenozoic time, the age of mammals, which is divided into three periods—Eocene, or early dawn; Miocene, or middle dawn, and Pliocene, or recent dawn of the existing state of things. Great mammals roamed through the dense forests of the Rocky Mountain region, which was a level swampy country. The temperature was tropical, and plant-life luxuriant. Here we find ample material for the study of the ancestors of modern animals. The horse had many ancestors, and their remains have been eagerly sought for. In early Eocene time he appeared no larger than a fox, with five toes on the hind feet. The folds of the tooth enamel were simple; later on he had discarded his two side toes and walked on three, later still only one toe on each foot was in functional use. The side toes were like the dew claws of a dog. The enamel was complicated and resembled that of the recent horse, that has only the rudiments of these side toes in the splint bones, and so the ancestors of other animals have been traced. The camel has two toes, and the two metatarsals and carpals are united, a medullary canal extending the whole length of the bone on each side. I was so fortunate as to find a camel in the miocene of Oregon that had the two metatarsals and carpals entirely distinct. In the Loup Fork Pliocene I have been employed the present season, for the U. S. Geological Survey, and have been remarkably successful.

My party having procured 15,000 pounds of fossil vertebrates. They consist chiefly of three species of rhinoceros, the mastodon, camel, horse, a small deer, lion, etc., all from one locality. Great numbers of bones have been washed from some river into a deep hole, in the lake, and everything in connection with

them prove that the place of death was but a short distance from that of burial. The bones were scattered through sand on a bed of calcareous sandstone. Rhinoceros bones were the most abundant; Cope calls them Aphelops. They were without horns, and had large sharp canines in the lower jaw, and also in the premaxilla. These were oblong in shape and ground against the lower ones, keeping them always sharp.

In some cases the premaxilla was several inches longer than the nasals, and had doubtless a flexible trunk. They had three toes on each foot, and were about the size of existing species. These beasts lived alone in herds, no other animal, no matter how fierce, would care to attack or associate with them, for in addition to their sharp tusks, their skin was thick and folded. The bones were indiscriminately mixed. It was not uncommon to find camel vertebræ between the branches of the lower jaws. We found several skulls with lower jaws attached and one perfect front foot. All the others were scattered, except the Tibia and Fibula that were anchylosed together.

A large mastodon lived at this time with inferior tusks. In 1881 I discovered a perfect lower jaw, that measured five and a half feet from the point of the tusk to the angle of the jaw; the jaw was four feet long. This season I procured four upper teeth together in fragments of the maxilla. The largest was seven and a half inches long and three inches wide. Turtles were also common; in 1881 I procured twenty specimens from a narrow gulch. Some of the shells were beautifully sculptured. They were all land and fresh water turtles. But time will not allow me to go more into details. If I have been so fortunate as to interest some of you enough to go more deeply into the subject than I have to-day, I shall be most happy.

THE NEW ARTESIAN WELL AT FT. SCOTT, KANSAS.[1]

E. H. S. BAILEY AND E. W. WALTER.

Some months since a company was formed at Ft. Scott to sink a well for the purpose of obtaining gas. The well was bored to a depth of 621 feet, and although gas was not found, an abundant supply of water was struck.

The well was bored on the first bench on the south side of the Marmaton River, at the foot of the bluff and 550 feet from the channel. Above the mouth of the well is a bluff consisting of limestone, hydraulic cement rock, coal, fireclay, and bituminous shale. The diameter of the well is eight inches down to 335 feet, to which point the well was tubed with iron pipe. Below that point the well was bored dry forty-five feet, at which point a fourteen inch crevice was struck and salt-water rose to within ten feet of the surface. The boring was continued till a depth of 621 feet was reached, and on removing the drill a clear steady flow of over 10,000 gallons of water per day was obtained. There seems

1 Abstract of a paper read at the Meeting of the Kansas Academy of Science, 1884.

to be a continuous flow, with but little gaseous agitation. The pressure will carry the water to a height of five feet above the mouth of the well. The water remains at this height till the altitude is diminished.

The drill record, which follows, as well as other interesting facts, were furnished by E. F. Nave, Esq., of Ft. Scott:

Wash-Dirt	25 feet.
Clay	5 "
Soapstone	15 "
Slate	3 "
Coal	2 inches.
Soapstone	15 feet.
Slate	2 "
Coal	2 inches.
Soapstone	17 feet.
Blue Limestone	3 "
Soapstone	95 "
Soft Sandstone	5 "
Soapstone	70 "
Brown Sandstone	25 "
Grey Sandstone	7 "
White Sandstone	25 "
Slate	12 "
Fire Clay	4 "
Soapstone and Clay	10 "
Slate and Iron-pyrites	5 "
Flint	23 "
Flint and Limestone	14 "
Crevice	14 inches.
Limestone	4 feet.
Limestone and Flint	75 "
Very Hard Flint	5 "
Mixed Flint and Limestone	156 "
Total	621 feet.

An analysis of the water shows it to have the following composition; the weights being estimated in grains per U. S. gallon of 231 cubic inches:

Hydro-Sulphide of Sodium	.188 grains.
Chloride of Sodium	79.471 "
Bi-Borate of Soda	2.204 "
Chloride of Potassium	Trace.
Chloride of Lithium	Trace.
Chloride of Magnesium	7.987 "
Chloride of Calcium	.787 "

Sulphate of Lime	.829 grains.
Bi-Carbonate of Lime	14.238 "
Bi-Carbonate of Magnesia	.305 "
Bi-Carbonate of Iron	1.006 "
Sulphate of Soda	Trace.
Silica	.951 "
Organic Matter	1.166 "
Total Solids	109.132 "
Sulphuretted Hydrogen Gas	Trace.
Carbonic Acid Gas	Trace.
Temperature of Water	67½°.

This may be classed as one of the sulpho-saline waters, containing borax and lithium as rare ingredients. Comparing this water with that of other springs and wells, we find it to be similar to the celebrated " Blue Lick " Spirng of Kentucky, except that the Ft. Scott water is more dilute and the former does not contain borax. From a consideration of the strata through which the well passes and the composition of this water, it seems probable that it is a mixture of waters from different depths.

UNIVERSITY OF KANSAS, Lawrence, December, 1884.

ENGINEERING.

THE STREET PAVEMENTS IN KANSAS CITY.[1]

W. B. KNIGHT, C. E.

There is nothing more characteristic of a city, and nothing which in such a conspicuous manner marks the distinction between a city in fact and a city in name, than the condition of its public thoroughfares. It is a sign more extensive and obtrusive than any other kind of public improvements. The difference between a clean, smooth, easy riding carriage-way and the rattle and jolt over a rough roadway with varying conditions of mud and dust, must inevitably form an important factor in any estimate or judgment of a city. It is, perhaps, a difference which may rank even with climatic influences in effecting the prosperity, temperament and other characteristics of a population.

Well paved streets in a city are at once the exponent of its commercial vitality and a mark of the wise exercise of municipal power for the conservation of a most important element of that vitality; an element as important to the health,

1 Read before the Civil Engineers' Club of Kansas City, November 29, 1884.

growth and prosperity of the body politic and commercial as the free circulation of blood in the veins is to the individual man.

It is the object of this paper to describe as briefly as may be done, the manner in which this city has paved its streets, the conditions precedent and relative thereto, and the extent to which this kind of public improvement has been carried in the short space of two years and a half.

Kansas City is divided topographically into two distinct parts, the main portion of the site being a high, broken ground, elevated 100 to 200 feet above the Missouri River, and the smaller portion being level "bottom land" lying beyond the base of the bluffs and only about twenty-five feet above low-water mark.

The soil of the upper town is a rather yellowish clay containing generally a small proportion of silica, and most of it is suitable in its natural state for making brick of fair quality. Some of it, however, contains too large a proportion of lime. It is very compressible in its natural state, rapidly forms into ruts and depressions under ordinary traffic on newly graded streets, even where formed entirely by excavation. It softens easily and becomes slippery, and is of greasy appearance. when moistened. Flowing water washes it away rapidly and carries a large proportion of it in suspension to fill up low places when the current is checked. It cakes to a hard crust under influence of drought and summer suns, pulverizes to fine dust under traffic, and cracks open during the severe frosts of winter.

The street gradients in the main part of the city may be stated as ranging from two to five per cent on the north and south streets, and generally about half as great on the streets running east and west—although on some of the latter are found the steepest grades in the city—varying from six to thirteen per cent. These occur on streets crossing Main Street, and in the central business portion of the city.

Notwithstanding these steep gradients, the loads actually hauled over them every day are very heavy and the wagon tires generally much below the proper width. The city ordinance passed last year requires a three-inch width of tire for loads up to 3,000 pounds, and a four-inch tire for loads not over 6,000 pounds. As a matter of fact, however, loads of 7,000 pounds are commonly hauled on wagons with two and three-quarter inch tires, and the ordinary two-horse wagons, carrying loads of 3,000 to 4,000 pounds, have tires usually only two inches wide.

The heaviest load of which I have information was hauled recently, being a piece of machinery for the Cable Railway Company, which weighed 22,400 pounds, and was hauled by eight horses on a wagon with three and three-quarter inch tires. It is estimated that 13,400 pounds of this load was on the rear wheels.

In the lower town the natural soil is a fine, light sand, which becomes saturated with water during flood stages of the river and in which there has been deposited, in the artificial process of filling up, a top layer of clay and debris ranging from one to three feet thick.

The widths of streets vary from fifty to ninety-nine feet, a majority of the

principal streets being sixty feet wide. A general law of the city makes the roadway three-fifths of the total width.

Street railroad tracks are usually of four feet gauge, laid four and one-half feet apart. The lines are as a rule, double track on business streets.

The rock found in and about the city is a common limestone—most of it very soft; there are, however, some ledges of hard blue limestone, and one of dark flint-rock. At Argentine, about four miles out of town, and at Edwardsville, are found considerable deposits of limestone in ledges, varying in quality from soft calcareous to firm granular rock containing a large percentage of silica.

The work of paving the streets of Kansas City may be said to have begun, properly speaking, in the spring of 1882. At that date there were ninety-three miles of streets within the corporate limits of the city, of which fifteen miles had been Macadamized, the remainder being simply dirt roads. This work was done at intervals during the preceding ten or fifteen years under substantially the Telford-MacAdam specifications, and consisted of a layer of stones eight inches deep roughly set on edge, with four inches of stones broken to two and one-half inches diameter spread on top. The sub-grade was not rolled or compacted in any way. The larger stones used were very irregular in size and shape, and were not carefully placed. The top layer was put on in one course without rolling or binding in any way, and the quality of the stone used was generally of the more accessible and softer kind.

This class of work was mainly confined to the principal thoroughfares and is very unsatisfactory in its results. The stone wears away rapidly under the heavy street traffic, or becomes pounded down into the soft clay underneath, so that in dry weather the surface is very rough and uneven, and in wet weather the streets are almost impassable. Repairs have consisted of simply dumping wagon loads of broken stones into the worst holes and ruts and leaving it to be compacted by the travel on the street.

The first cost of this kind of street improvement was about fifty-seven cents per square yard. The cost to the city at large every year has averaged, I estimate, $1,000 per mile, although, probably, on some of the main traffic streets, the cost has been much above the average. Correct figures are not obtainable.

The stone for repairs is furnished without first cost, and the breaking is done by the work-house prisoners at a nominal expense.

In the spring of 1882 all of the principal streets were in very bad condition. The first contract for paving any street otherwise than by Macadamizing was let February, 1880, and included that part of Fifth Street between Broadway and Bluff Street. The specifications called for Medina (N. Y.) sandstone, cut after the Belgian form, six to seven inches deep, laid on a six inch bed of coarse sand, and with the joints between the blocks filled with asphalt paving cement. The cost was $3.50 per square yard. The work was not, however, completed until January, 1883. Meanwhile the second contract had been let, in February, 1882, for paving that portion of Wyandotte Street between Fifth Street and Ninth Street with round white cedar blocks, six inches long, set on one-inch boards, bedded

on three inches of sand. The spaces between were rammed full of sand, and a coating of asphalt paving cement spread over the surface. The cost was $1.75 per square yard.

These two contracts were not preceded by any special public consideration of the subject generally, and were, as to kind, mainly the result of accident and individual interests.

The question of the proper kind of pavements for our streets came up in June, 1882, prominently in connection with the improvement of Sixth Street, between Delaware and Bluff Street. This street had just been regraded so as to form a new avenue for travel to and from West Kansas, and with the expectation, which has since been realized, that it would immediately become a main thoroughfare and leading business street.

Under the law of this city, the paving of any street cannot be done by the authorities until the owners of property along the street, representing the majority of the front feet (exclusive of non-resident ownership) shall formally petition the common council to have the work done. It is also necessary that the property-owners shall specify substantially what kind of pavement they want laid down. The entire cost of the work is assessed against the property fronting on the street.

The property-owners on Sixth Street selected a committee to consider the various kinds of pavements suggested, and finally decided, upon my recommendation, to put down a substantial concrete base nine inches thick, with a cedar block seven inches long for a wearing surface. The specifications which I prepared at this time have governed, without material change, all work of this character done since then, excepting that the thickness of the concrete foundation is made on some streets six inches, instead of nine, as on Sixth Street, and six-inch blocks have been put down on some of the streets instead of seven. The leading features of the cedar block pavement, put down in this city, are as follows:

The roadway is excavated to proper depth, and made to conform to the shape to be given to the finished surface of the pavement. Care is taken to secure, as far as possible, uniform density of the sub-grade, by the use of a two-ton roller, (the only one available), and by filling in soft spots with broken stone and ramming them down into the soil.

On this sub-grade is placed a layer of hydraulic cement concrete nine inches thick on some streets, and six inches thick on others, depending principally on the character of the formation, location, and character of the street, whether it is a business thoroughfare, or a street in a residence part of the city. In an exceptional instance the depth of the foundation has been reduced to four and one-half inches by the property-owners, although, generally, the popular disposition has been in favor of the nine-inch base on streets of all kinds.

The concrete is composed of five parts by measure, of clean limestone, broken to go through a two and one-half inch ring, and two parts of clean coarse river sand, with one part of approved hydraulic cement. The sand and cement are thoroughly mixed dry, and then wet, and the mortar spread over the stones, which

are spread out in a layer in a box. The mass is then thoroughly mixed together and loaded out into a wheelbarrow, deposited in place, and rammed until the mortar flushes to the surface. The cement is required to stand thirty-five pounds tensile strain per square inch after twenty-four hours. The brands used have been "Fort Scott," Kas., "Milwaukee," and various kinds of Louisville. On the surface of the concrete, which is made to conform to surface of street, a layer of sand is spread about one-half inch deep, or sufficient to fill up all the minor irregularities of the surface of the concrete, and make an even bearing for the blocks. The blocks are of white cedar, varying from four to eight inches in diameter, and are required to be cut from good sound live timber. They are usually seven inches long when set on nine inches of concrete, and six inches on the lighter base. They are sawn with parallel ends by gang saws, and are laid up as close together as practicable in the street. The interstices between the blocks are twice swept full of gravel, which ranges in size from one-quarter to three-quarters of an inch, and rammed down with round-pointed iron rods. After the first ramming, the surface of the block is made smooth and uniform wherever it may be uneven by going over it with a light paving rammer.

Asphalt paving cement, composed of coal-tar, distilled at 300° to 400°, and mixed with fifteen percent of mineral asphalt, is poured hot over the pavement, filling up all the minor interstices between the blocks. A thin coating of sand is then thrown over the surface before the asphalt dries.

The first prices at which this kind of pavement was let were $3.25 and $2.96 per square yard, for parts of Fifth and Sixth Streets, in the spring of 1882. This was for seven inch blocks on nine-inch concrete. Since then the cost of this work has been constantly decreasing with each successive letting. The last work contracted for was let at $2.44, and the average price paid during the season was $2.56. For six-inch blocks on six-inch concrete, the price has varied from $2.32 on the first, to $2.18 on the last contract let.

The ordinary wages for common labor has been $1.75 per day. The materials used cost about as follows: Seven-inch cedar blocks, eighty to eighty-five cents per square yard measured in the street, and six-inch blocks about seventeen cents less. For gravel, ten to twelve cents per square yard of pavement with seven-inch blocks. For asphalt paving cement, fifteen to eighteen cents per yard. The broken stone for concrete costs $1 per cubic yard, and sand about the same. Cement varies from $1 to $1.25 per barrel of about 260 pounds. The concrete in place is worth about $3.50 to $3.75 per square yard. One block of seven-inch cedar block pavement has been laid during this year on one-inch boards with four inches of sand underneath at a cost of $1.95 per square yard.

Observations of the wear of cedar block pavement with concrete base show a good, smooth surface and very uniform wear.

Blocks taken up at the intersection af Fifth and Main Streets, in the center of the business part of city, eighteen months after laying, showed a very regular wear of one-quarter to three-eighths of an inch. Blocks taken up for water and gas connections on the most crowded parts of Fifth and Sixth Streets, where

nearly all the heavy loads are confined to the ten and one-half foot strip of paving between the railroad track and the curb, show a wear of about three-eights of an inch in nearly two years.

There has been no repairing done on these streets, and there is no indication that any will be for some time. At all places where the pavement has been broken into, the concrete is found to be hard and compact. In one instance it was carrying the traffic of the street over a hole four feet across underneath. The bituminous concrete between the blocks has always appeared well formed, with but few voids occasionally near the bottom. The blocks are so thoroughly fastened together that sections of four to six square feet have been taken up without breaking. No swelling of the blocks and raising from the concrete has been observed. In very cold dry weather fine cracks appear running nearly directly across the surface of the pavement. They usually occur on steep grades and open from one to one and one-half inches if the extreme low temperature continues, but close up again with warmer weather.

The first stone pavement laid after the Medina stone, on a part of Fifth Street, was on a part of Bluff Street. Owing to the exceptional location of this street, no petition from adjoining property-owners could be expected, and in view of the public importance of this thoroughfare an appropriation of $15,000 was made out of the general fund to pave it. It was expected that a sufficient thickness of the old MacAdam metal would be found to form a good foundation on most of this street, considering the tons of broken stone that had been hauled there during the previous years. In the absence of this the specifications called for a six inch concrete foundation, which, in fact, was found necessary over the whole street. On this was placed a layer of two to four inches of sand. Rectangular blocks of the Argentine, or other good quality of native stone, was used for the wearing surface on my recommendation. The work could not be put under contract until late in the season, and consequently the eastern half, below Sixth Street, was prosecuted during the worst kind of winter weather—with the subgrade constantly wet from side-hill drainage, rains and snow, and was dug up to considerable extent by the gas company.

New quarries were opened and much of the stone laid in frosty condition on frozen sand; only the most urgent public necessity could justify doing the work under these circumstances. The western half remained unpaved and in nearly impassable condition, until early in the following spring. Meanwhile the large volume of the heaviest traffic in the city was turned on to the new pavement. This pavement cost $2.95 per square yard, or about $2.35 exclusive of the concrete base.

A line of three-inch agricultural tile drain pipe was laid along each side of the street near the gutters—that on the east side being for the purpose of draining the wet soil at the base of the hill, along which it runs—and that on the west side for sub-drainage and protection of retaining-wall.

Observations of the wear of this paving show numerous minor depressions of the surface, principally along the east side, and are due partly to unequal

wear of the blocks, and partly to settling of some of the numerous excavations made and imperfectly refilled, just in advance of the pavement. The principal objection to this stone is the variations in quality and consequent unequal wear. Although the effort was made to secure, by inspection at the quarries and on the ground, uniformity in quality, still the result shows that this has not been fully attained, and is, I think, impracticable for large quantities under the existing conditions. A large proportion of the stones indicate good wearing qualities, and will probably last for fifteen years, but the more rapid wear of the softer kinds makes a rough pavement and brings undue wear upon the others.

This material is extensively used by the street railroad companies for paving between their tracks, without any special selection as to quality used or shape of blocks, and without adequate foundation or care in laying.

A very superior quality of sandstone block pavement has been laid during the past season on Union Avenue. The stone is a firm, small-grained, metamorphic sandstone of pinkish color, quarried in the foot-hills of the Rocky Mountains, in Boulder County, Col. It lies in well defined and fully separated ledges varying in thickness from one inch to several feet. The ledges selected for paving stones are from three to four and a half inches thick, and the blocks are cut out from eight to twelve inches long and six inches wide. The Union Avenue pavement has a concrete base of nine inches, with two inches of sand on top, and has the joints swept full of sand. The side joints are smooth, corresponding to the natural top and bottom beds of the stone in place, and the ends re-cut to lay to one-half inch joint.

This pavement cost $5.38 per square yard, or about $4.25 exclusive of concrete. The stone costs on cars here, about $2.50 per square yard, measured as laid. Portions of this pavement that has been under heavy and continuous traffic since first put down, indicate excellent wearing qualities. A part of Mulberry Street, West Kansas, has also been paved with this stone, on a nine-inch bed of sand, with a well prepared sub-grade. East Ninth Street, from Main to Grand Avenue, is now being paved with the same material, on six inches of concrete. The grades on these two blocks are eight and thirteen per cent.

Walnut street from Twelfth to Twentieth, about 4,600 feet, was macadamized last year. The stone was carefully selected for hardness, and was broken to size from three and one-half inches to two inches. They were spread on in three layers, one of five and two of four inches each, making a thickness when rolled of thirteen inches at centre of roadway, and eight inches at gutters. The top layer is of very hard flinty rock and was mixed with a binding material of sand and clay; the only roller available was an old one weighing about 4,000 pounds and was altogether too light to compact the metal. There was considerable travel over this street while the work was in progress, forming well-defined ruts in the loose stones along the center. The street has been carrying a large and heavy traffic for a year now, and is in very good condition, although it has had no repairs at all. This work cost sixty-three cents per square yard.

A portion of Hickory Street, in West Kansas, about half a mile long, was paved under the Telford-MacAdam specifications, at a cost of seventy-eight cents per square yard. It has had no repairs since completed, and has been carrying a very large traffic with reasonably satisfactory results. The character of the pavement on these two streets, was due, in the case of Walnut Street, to the strong preference of a few active property-owners; and in the case of Hickory Street to the impracticability of getting a majority of the property-owners to agree upon any better kind.

A large amount of good macadam pavement might properly be put down on certain streets, provided the city had a heavy steam roller to use in construction, and, in addition, a well organized and equipped force to make repairs. Under present circumstances I think it is bad policy to improve streets—especially business streets like these—in this way.

All the materials used and the execution of the work is under constant supervision—one, and frequently two, inspectors being assigned to each piece of work. The whole work is under the immediate charge of the Superintendents of Construction, and care is taken to insure good workmanship and a substantial compliance with the specifications throughout.

The drainage system of the street surface is from the center each way to the gutters, and along the gutters to sewer inlets at nearest street corners.

The standard form for paved streets makes the pavement at the center of the street level with the curbs, and thence sloping down on curved lines to eight inches below this level at the curb line, excepting in the case of macadam streets, which are designed to have twelve inches fall to the gutter. Considerable variation, however, is found to be necessary on account of the existence of single or double lines of street railway tracks along the center of the roadway, and frequently on account of streets where the old established grade varies from "level across" to three feet higher on one side of the roadway then on the other. Some modifications are advisable, too, in cases of steep longitudinal grades, but the general purpose has been not to make the cross-slope greater than eight inches in eighteen feet, and to make the gutter not less than six nor more than twelve inches deep.

Starting in tne spring of 1882 with seventy-eight miles of dirt streets out of the total of ninety-three miles in the city, and the remaining fifteen miles of old Telford-MacAdamized streets which included all of the business streets, the work of paving done since then has been at follows:

	Miles paved.	Cost.
In 1882.	0.98	$ 31.137
In 1883.	2.63	132.755
In 1884.	9.03	442.167
Total	12.64	$606.059

We have taken up five and two-thirds miles of old MacAdam pavements and replaced them with stone or wood blocks.

	Miles.
There are now in the city, of old MacAdam pavement, about	9.3
Of new MacAdam	1.3
Of cedar blocks on concrete foundation	9.6
Of stone blocks on plank foundation	0.64
Of stone blocks on concrete foundation	0.7
Of cedar blocks on sand foundation	0.4
Total paved streets	21.94

Most of this work has been done on streets in the business part of the city. The work projected for next year will probably increase our mileage of paved streets by eight or ten miles, although as the initiative of this matter must in every case be taken by the owners of property on the streets, it is difficult to predict what the extent of work will be.

Excavations in newly paved streets have been carefully attended to with the object of preventing this prolific source of destruction to pavements. Permits are only given to parties who have obtained a proper license after filing a bond of $1,000 and depositing $25 in cash with the city treasurer, subject to the order of the city engineer. The conditions I have required of all parties who desire to make excavations in paved streets for gas, water and sewer connections, provide that the trenches shall be refilled with small broken stones, mixed with only a moderate proportion of clay, put in and thoroughly rammed in twelve inch layers. The sides of the excavation at the top are sloped out and double the original thickness of concrete put in, and the blocks replaced in a workmanlike manner. A special inspector is employed for the purpose of securing good work. As a rule, this has been accomplished and the pavement restored to its original condition and without subsequent settlement. This is considered a very important matter, and the requirements are based upon the principle that no individual has the right to damage a street pavement if it is practicable to prevent it. The Water-Works Company and the Gas Company have a general right to dig up the streets without legal restrictions, which is essentially wrong in principle, but practically, in this city, these companies have usually manifested a disposition to comply with proper requirements.

The general law of the city requires that railroad companies shall pave the space between the rails of all tracks, and a space of eighteen inches on the outside of each rail in the same manner as the roadway outside of such tracks may be paved. Great difficulty has, however, been experienced in getting this work done right, and practically the paving done by the companies is of a very inferior kind.

A good deal of special argument has been made against the use of concrete on that portion of the street to be paved by the company, as impracticable, but I am of the opinion that it is not quite practicable to use the concrete foundation,

but that it is eminently desirable that it should be so done, and that the foundation for all the paving should be uniform on every part of the street.

Some modification of the present method of track construction is advisable along streets with a concrete base, and it would appear to be a good, sound principle of public policy that the track paving should be made to conform to the street work, rather than that a special and objectionable modification should be made to suit the interests of the railroad companies.

In conclusion, I would express my opinion that the use of the concrete base, which is a characteristic feature of street pavements in this city, is right and proper. It is the most essential feature of a good street pavement, and it is noteworthy that this foundation should meet with such popular approval, and that this new city should be the first in the country to start right in this vexed problem of street paving. The main part of the street pavement is down for all time, and the wearing surface may be renewed when worn out, or changed and improved, as may be hereafter deemed best, at comparatively small cost.

I venture the prediction that Kansas City will, if this plan is continued, waste less money and profit more by the experience of the world in this matter than any other city that can be named.

A NEW STREET CAR RAIL.

The owners of light vehicles, the street car companies, and the stranger within our gates will be glad to be informed that a tramway rail has been invented which not only admirably serves the purpose for which it is designed, but can be laid in such a way as to leave the street as smooth as though it was not there. A rail of this kind is now in almost general use in the principal cities of Great Britain, and is found to work admirably. Its cost is not greater than that of the very objectionable T rail now in use here; it can be laid in almost any kind of asphalt, macadam, or stone block pavement without wooden ties or stringers, and when once laid becomes almost permanent.

Leaving out altogether the damage done to vehicles, the question whether or not the beautiful streets of our city are to be ruined by these tramways is one which should be carefully considered. I remember very well the appearance of some of our streets when I left home last summer. On Pennsylvania Avenue the unsightly appearance of the cobble-stones and the paving adjacent to the rails made a disagreeable impression. In some places the concrete extended to the rails, and in other places stonework extended for a short distance, alternating with the concrete. In some places whole slabs of stone, four or five inches wide and four feet long, were placed next to the rails. There was no symmetry whatever in the whole track and it resembled altogether an immense patchwork. When repairs were made no attention seemed to have been paid to making the track even or level, and, in consequence, numerous hillocks of cobble stones were the result. On Seventh, Ninth, and F Streets these evils were increased

by the numerous ruts in the space between the tracks as well as along side the rails. These ruts were caused by wagons having a broader gauge than the tracks being compelled to make use of them for various reasons. I suppose these matters have not claimed the attention of the commissioners.

The tramways in Liverpool are the perfection of the system employed on this side of the water, and I will endeavor to give you a crude idea of their appearance and construction. The Liverpool lines as now laid are conclusive proof that when tramways are well designed and properly constructed there is not the slightest impediment even to the narrowest-wheeled vehicles. The formation of the proverbial rut is impossible with this tramway and after completion it presents a symmetrical and smooth surface of great durability. The grooved rail I have mentioned is best shown by the following illustration, and in connection with it I have drawn the wheel in use. The groove is about three-quarters of an inch wide and the flange is in the middle of the wheel:

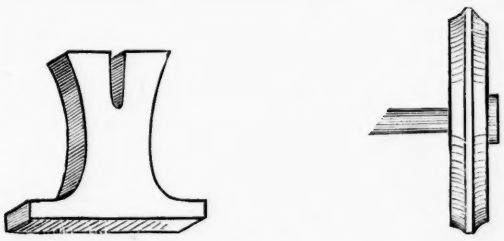

FIG. 1.

The following figure represents a section of the foundation and the track as completed. It will be seen that the rail is flush with the granite blocks and the latter on a level with the surface of the paving of the street, which in Washington would be the concrete shown in the illustration:

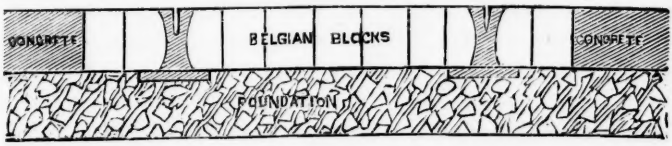

FIG. 2.

The bed or foundation consists of concrete mixed, and laid in the manner usually adopted for our street work, and formed to within about seven inches of the surface of the street. The surface of the concrete is carefully finished to the exact cross section of the paved roadway. This concrete consists of six parts of perfectly clean river or sea gravel, and eight of hard stones broken as angularly as possible, to one part of Portland cement.

The space between the rails and track and for eighteen inches on either side

of the roadway is paved with Belgian blocks. The sets are squared throughout, accurately gauged and laid in straight and properly bonded courses, and evenly bedded in concrete. The joints of the sets are filled with cement. These blocks resting on a firm foundation, there is no possibility of the settling of the roadway.

The cost of building a tramway of this kind is small in comparison with its great durability and the great blessing it would be to the public. If this tramway is introduced in America, and in Washington particularly, it will be a complete success and give entire satisfaction to the public.—*Correspondent National Republican.*

THE PROBLEM OF RAPID TRANSIT SOLVED (?)

Mr. John R. Abbe, an engineer of St. Louis, has proposed a scheme for rapid transit, which for ingenuity and magnitude exceeds any yet offered to the public. It is the result of two and one-half years' labor commenced while in Manchester, England, and finally concluded in St. Louis.

The first condition requisite for this great railway, according to Mr. Abbe is that the road-bed have no curves of less than 3,000 feet, and no grades of more than twenty-seven feet to the mile. This would in the construction of the road necessitate the removal of mountains and the filling up of valleys, but these are some of the obstacles that the capital required is expected to overcome. The reason for making the curves so gradual and the grades so slight is, as may be easily conceived, on account of the tremendous rate of speed at which this ideal express train will travel. It is also necessitated in part by the width of the track, which will be, when constructed, nine feet between the outer rails.

These rails will, when laid, be of ordinary pattern, though heavier than the ordinary rail, or with a face of about four and a half inches. Midway between the outer rails, will rest another of the same weight, but different in pattern, being angled on both sides from the top. The reason for having this rail angled is that on either side of it may run friction rollers connected with the car, which will thus be guarded against the likelihood of a leap into space when it is progressing at the rate of three miles a minute between the two great metropolitan cities of the United States. All three of these rails will be seven inches high, with a base of seven and one-half inches resting on ties of metal. The entire road-bed, when laid out, will be fenced in from communication with the world and all cities, towns, streets, country-roads, and cattle will have to keep out of the path lest they should delay the progress of the ideal express.

The road-bed having been laid out, the ties and rails placed in position, and a glass roof placed over the whole. Mr. Abbe presented a plan of the engine and cars which are expected to overcome the forces of nature, or, rather, utilize her power in overcoming the obstacles which she has placed in the way of rapid travel. The care which takes but a passive part in the performance, is iron-

plated. The first train may, in honor of the event, be silver-plated, but the general idea is that, for the preservation of the cars, they be covered with sheets of metal or be constructed of metal throughout. The general shape of the conveyance will be that of a cigar.

For the engine which is to travel over the rails at such a tremendous rate of speed, Mr. Abbe has devised several improvements in cylinders, valves, seats, etc., which, as they are of value to him and he hopes to have them patented some day, are not described here. The general appearance of the engine is that of three huge wheels preceded by a sloping frame and followed by a tank, from the top of which rises a short smoke-stack. The tank contains the water which is scooped up in transit from huge troughs between the rails. Through the tank to the smoke-stack runs a pipe which, coming from the fire within the boiler, heats the water in advance. Beneath this tank is a center-pin truck, with two pair of weels, a companion to which supports the head of the locomotive. Upon these trucks rests the huge framework, which is bowed like a bridge and whose oscillations, according to Mr. Abbe, will therefore be vertical, and not horizontal. The driving-wheels which propel this piece of mechanism are to be three in number, resting upon three rails. The center wheels runs quite ahead of the other two, but the pistons which operate it work from the other side of the same steam-chests that furnish the power that propels them. The driving-wheels may be flanged or not, according to the desire of the passengers. The engine will be held upon the rails by the action of small wheels running horizontally or at angles of 45° on the sides of the middle rail. The diameter of the truck-wheels will be nine feet. The three driving-wheels will be twenty-four feet in diameter, giving a piston speed of 1,470 feet per minute to make the three miles which Mr. Abbe expects his machine to cover in that time. "The shaft that has the two wheels," according to Mr. Abbe, "has cranks on the inside of journals, the center of pin corresponding with the center of engines. Then when engines are placed midway between the single and double drivers allows the double pair of drivers to govern the machine when running, while the single wheel, running on the center rail, is allowed an easy motion in conformity to the engines."

The engineer who manipulates rhe reverse and the cut-off for the ideal express will occupy a position of some prominence, his domicile being placed between two of the big driving-wheels and behind the third. The fireman and engineer will be widely separated, the fire-boxes being close to the ground and extending on either side of the forward driving-wheel. Thus the engineer will have to be his own lookout. The peculiar advantages of the position given to the cab are said to be the vertical control over the engine and the superior view of the track.

The engines will have cylinders 30x42 inches in diameter and the open portions of the skeleton frames will be filled in with a non-conducting substance of asbestos and plaster-of-Paris, which will retain the heat and prevent condensation in the cylinders. The boiler will be placed on the lower frame under the crank shafts. The coal bunkers are in the extreme forward end of the machine

just ahead of the fire-boxes. The weight of the boiler is evenly distributed, and by placing the heavy parts of the machine so near the rail a swinging motion is prevented when the engines are in operation.

In conclusion Mr. Abbe states that 300 pounds pressure will be necessary in the boiler. Now these important questions, he says, arise: Can such piston-speed be used? Can packing be made which will stand such friction and metal bearings which will keep cool? Can steam be made fast enough with the boiler in such a position? Can men be found to fire such a machine or run it? Will people ride at such a rate of speed? These, of course, are minor points, however, and easily overcome. The main questions have been solved in this article and rapid transit is now an assured fact. It is to be hoped that Mr. Abbe will hasten to enter into a contract with the projector of the tunnel between England and America under the Atlantic, so that his ideal express may in the hereafter be utilized, not only for trans-continental but for inter-continental travel.—*Globe-Democrat.*

STAMPED RAILWAY WHEELS.

The following account of the manufacture of railway wheels by stamping at the Blast Furnace, Forge and Steel Works, St. Chamond, is from *Revue Generale des Chemins de Fer*, and was translated in the abstracts of the British Institution of Civil Engineers: "The wheel centre is constructed in three operations—the formation of the rough piece, the rolling into shape and to the diameter, and the finishing off. The processes are a little different for working in iron and in steel. The description applies to a wheel center of the Western Railway having an undulated web of about three feet in diameter and weighing 495 pounds. A wrought-iron pile is made up of six layers of bars, eight inches by four wide, cut to a circle twenty inches in diameter, placed between two flat rings of iron, one above and one below the six layers, keeping them in and binding them. Three rings of one and one-half inch square iron, seven or eight inches in diameter, are piled upon the layers as materials for the nave. After the hammering for the first heat, the slab is inverted and three more rings are placed on the other side for the other portion of the nave, and for the second heat. With two more heats, making four heats in all and five or six blows of the hammer in each heat, the forging is completed. The central opening is punched out in the operation of stamping. For the manufacture of steel centers a very mild steel is used, having a tensile strength of from twenty-five tons to thirty tons per square inch, and an extensibility of twenty per cent. A special ingot weighs, for one of the Western wheels, 530 pounds. The work is done in two heats. The ingot is heated, in the course of an hour or an hour and a half, to a white-yellow. It is placed for hammering in the position it occupied in the mold, and any blown holes that may be present in the bloom are likely to be removed in piercing for the nave. Each hammering requires from five to ten minutes; the second heat

only requires twenty minutes. The rim and the web are rolled to form in one heat by rollers similar to those employed for rolling tires. In the same heat the center is finished under a fifteen-ton hammer. Steel centers are annealed by being raised to a cherry-red heat and cooled slowly, covered by iron plates. Centers of steel and of iron have been tested for strength by the falling of a weight of seven tons upon the nave, the center being supported horizontally at the rim. The steel center resisted without fracture 210 blows of the hammer falling from eight to eighteen inches. The nave was depressed four inches. An iron wheel broke with 150 blows on a fall of from eight to twelve inches.

WASHINGTON MONUMENT COMPLETED.

The long expected completion of the Washington Monument obelisk was accomplished on December 6th by the setting in place of a marble cap stone and its pyramidal apex of aluminum. The ceremonies were few and simple, an elaborate celebration of the event being reserved for Washington's birthday. Shortly after 2 o'clock Col. Thos. L. Casey, Government Engineer-in-charge, and his assistants, Capt. Davis, United States Army, and Bernard R. Green, civil engineer, together with Master Mechanic McLaughlin and several workmen, standing on a narrow platform built around the stopped marble roof near the summit, proceeded to set the capstone weighing 3,300 pounds, which was suspended from a quadropod of heavy joists supported by the platform and towering forty feet above them. As soon as the capstone was set, the American flag was unfurled overhead and a salute of twenty-one guns fired by a battery in the White House lot far below, the sound of cheers also came up faintly from a crowd of spectators gathered around the base of the monument, while a number of invited guests were on the 500 foot platform, and on the interior of the foot of the monument at that level spontaneously struck up "The Star Spangled Banner" and other patriotic songs. A steady downpour of rain had given place a little while previously to a brisk gale of wind which, at this elevation, was blowing about fifty-five miles an hour, and very few invited guests cared to avail themselves of the privileges of climbing the nearly perpendicular ladder from the 500 foot platform to the dizzy height of 533 feet from which three or four journalists and a half dozen other adventurers climbed and witnessed the setting of the capstone, and subsequently ascended to its pinnacle.

Meanwhile the Washington Monument Society, represented by Dr. Joseph M. Toner, Hon. Horatio King, Gen. William McKee Dunn, Dr. Daniel B. Clark, and T. L. Harvey, Secretary, held a meeting on the elevated platform at a height of eight feet, and when the artillery firing announced the setting of the capstone, adopted a resolution offered by Gen. Dunn congratulating the American people on the completion of this enduring monument of our nation's gratitude to the father of his country.

Among those present to-day at the completion of the structure was one of

the master mechanics who laid the corner-stone of this monument more than thirty-six years ago, and the old watchman of the monument who has been continuously employed in that capacity during nearly the whole intervening period. The flag over the monument floated to-day from the flagstaff-top, which is exactly 600 feet from the ground, thus displaying the American colors at the greatest height ever known in the world. The monument itself, with its height of 550 feet, far overtops every other structure of human hands. The aluminum apex of the monument is engraved with inscriptions, as follows: On one face

> "Chief Engineer and Architect, Thos. Lincoln Casey, Colonel Corps of Engineers. Assistants Geo. W. Davis, Fourteenth United States Infantry; Bernard R. Green, Civil Engineer; Master Mechanic P. H. McLaughlin."

On another:

> "Corner stone laid on the bed of the foundation July 4, 1848. The first stone at a height of 152 feet, laid August 7, 1880. Capstone set December 6, 1884."

On a third:

> "Joint commission at the setting of the capstone, Chester A. Arthur, W. W. Corcoran, and Chairman M. E. Bell, Edward Clark, John Newton, Act of August 2, 1876."

And on the fourth face the words:

> "Laus Deo."

The capstone is a cuneiform keystone four feet five and three-quarter inches on the outer faces in height, with a shoulder on each side of seven inches to tie the ashler face of the pyramidal cap; below this shoulder the stone is ten and a half inches, making the total length from top to base five feet two and a half inches. The stone at the base is three feet nineteen-seventeenth inches square, and at the cap where the aluminum tip is to be placed, the diameter is exactly five inches.

The aluminum tip is something new in monumental architecture, and its use is for two purposes. It is freer from oxidation than any other substance that could be used, and it is of exceptional value as a conductor of electricity, serving, in this case, as the tip of both monument and the lightning-rod. It will be secured in its place by a wrought copper rod, leading down through the center of the capstone, and below will connect with each of the four columns that form the elevator frame in the main shaft. At the base of the monument, these leaders will be conducted to the well beneath the center of the foundation, thus forming the most perfect electrical conductor known to science.

The capstone was set by the following means:

Beginning a few feet above the main shaft, on each of the four sides of the pyramid, four heavy joists are placed, and on these, thirty-three feet above, is built a platform extending around the cap. Extending up from this platform are four joists, one at each corner of the structure, which meet forty feet above and support a tackle with which the remaining stones are handled. To the point where the platform is built all the stones of the pyramid were handled with the mast and boom that extended from the interior framework, but as the cone narrowed, the spar was removed and the outside frame built. Before this, however, all the remaining stones were hoisted to the platform and handled from there. When the capstone is set this afternoon and the tip placed in position and fastened to the copper rods below, the upper joists will be removed and lowered by the men, and as the platform and its supporting-frame is taken away and lowered, the remaining men will work from a temporary platform hung from skids or joists projecting from the window, which has been cut in the east face of the last course below the cap. This window is three feet long and two feet wide, and after the last timber has been lowered and the last man has entered the pyramid the hole will be closed by a stone, which accurately fits, and cemented in place. The lower platform and the guard-netting at the 500-foot level will be removed through the hole at the base of the pyramid, which was left to pass the upper stones outside from the elevator. When this is done the stones belonging there will be set and the whole structure from foundation to the aluminum tip will present an unbroken appearance. The narrow windows in each face of the pyramid, which are four feet above the 500-foot landing, will be fitted with heavy marble shutters, which are to be worked by ingenious machinery inside. These windows, which seem like tiny streaks from the ground, are each three feet long and eighteen inches high, and are eight in number, two on each face, giving a perfect view of the surroundings.

The corner-stone of the monument was laid with imposing ceremonies July 4, 1848, and the work for several years was paid for with money derived from popular subscriptions. The source, however, soon failed, and after about $200,000 had been expended the work ceased, and during the years that elapsed from 1852 until 1859 the unfinished shaft (which resembled more the whitewashed chimney of a huge factory) was this nation's disgrace. Finally, on Independence day of the Centennial year, Senator Sherman presented a resolution declaring it to be the sense of Congress that the monument should be completed. The resolution and the necessary appropriation to begin the work anew was passed by both houses unanimously, and since then the work has progressed steadily.

In 1876 the monument had reached the height of 152 feet above the foundation, and about $260,000 had been expended on its construction; $900,000 has been expended under appropriations of Congress. The corner-stone, which was cut from the same ledge of marble (near Cockeyeville, Md.), from which the marble of the shaft has been taken, weighed a little more than twelve tons, and was laid at the north-east corner of the foundation.

Very soon after the appropriation of 1876 became available, Colonel (then lieutenant colonel) Thomas Lincoln Casey, corps of engineers, U. S. A., was designated by President Grant, through Secretary of War McCrary, as the engineer officer to conduct the work, and Captain George W. Davis, 14th U. S. infantry, was ordered here from Texas and placed on special duty as an acting engineer officer, as assistant for the monument construction.

The first work done was in 1877, when shafts were sunk at different points about the monolith and borings made to find the character of the strata below the foundation. It had already been ascertained that the original foundation extended only five feet below the surrounding earth surface, while fourteen feet reached above to the floor of the shaft. The examinations showed that below the old foundation was a series of layers of yellow and blue clay on a rock strata, sloping away to the original bed of the adjoining Potomac, and that these beds of clay were thickly strewn with huge boulders of the ice-period. The clay taken out was tested for compressibility, but the examinations and tests showed that, to sustain the huge structure of over 81,000 tons, the foundation should rest upon the bedrock, still fifteen feet below. These examinations and the studies of the subject made by Captain Davis continued until 1878, when finally the plan of building a new foundation beneath the old one was decided upon, to the astonishment of engineers all over the civilized world. How such a thing could be done was the wonder until Colonel Casey and Captain Davis practically demonstrated it by accomplishing the fact.

The old foundation was so ridiculously shallow and narrow in base that the addition of the weight necessary to carry out the design of height would have sunk the structure into the ground, much like thrusting a cane into moist earth, or, more likely, have toppled it over toward the adjacent Potomac flats. A new and wide foundation was built under the old one and resting on the bedrock beneath. The magnitude of this before unheard-of feat of engineering was so great that home and foreign civil engineers visited the work to see for themselves that it was actually being done. The complete work of the sub-foundation is one of the greatest feats of engineering known in the world.

Meantime, while the foundation examination had progressed, means had been found to reach and examine the top which was left unfinished before Congress took action. The three upper courses of stone, each one two feet high, were found to be so damaged by the action of frost, and perhaps lightning, that they were removed before the work on top was resumed at the exact height of 150 feet.

September 11, 1878, an inspector of the proposed work and Mr. P. H. McLaughlin reported at the monument grounds, and were followed next day by a small gang of carpenters, of which Mr. McLaughlin was then the foreman, who began the erection of the necessary buildings. The first superintendent, who reported in the same month, was Mr. Navarre, and on his resignation in 1879 Mr. McLaughlin was promoted from master carpenter to succeed him.

August 7, 1880, the first stone above 150 feet from the foundation was laid, and to this date Mr. McLaughlin has superintended the whole of the work.

Since the commencement of work on this monument the States of California, Oregon, Minnesota, Kansas, Nevada, Nebraska, and Colorado have been admitted into the Union, we have chronicled the history of nine political administrations, witnessed the birth and death of political parties, and passed through a terrible civil war and four financial strains, and established the best banking system in the world. The great republic in the meantime has grown from 23,000,000 to 55,000,000 people, and in material wealth from $7,400,000,000, or $320 per inhabitant, to $57,000,000,000, or about $1,000 per inhabitant. When the National Monument was begun Great Britain possessed five times the wealth owned by the United States, and while the wealth of the former country has only doubled within the past four decades, that of the latter has increased twelvefold. As to the constituent factors of American progress in their aggregate in the four decades they are sufficient to buy up the whole Austrian Empire several times over, or pay for the aggregate value of the "effete" monarchies of Italy, Holland, and Belgium almost three times over during that period. Our tilled acreage has increased from 50,000,000 to 170,000,000 acres, the crops have increased in value from $415,000,000 to $2,500,000,000, and the cattle have increased in value from $380,000,000 to $18,400,000,000. Our imports have increased from $178,000,000 to $668,000.000, and our exports from $152,000,000 to $836,000,000.

The work is by no means completed now, for it will take many months, and perhaps several years, to complete the pedestal and finish up the surroundings.

The joint commission in charge of the monument has recently submitted to Congress a report showing its progress during the past year. The report shows the weight of the monument is 81,120 tons, and it has cost $1,187,710, of which Congress appropriated $887,710. In relation to the completion of the monument the engineer in charge of the work submitted a report with that of the commission. He says: "Two methods of treating the terrace at the foot of the shaft have been suggested. One method proposes to erect a retaining wall of the most beautiful marble around the terrace, which wall is to be surmounted with marble balustrade. At the centre of each face is to be set off, broad double stairs extending from the general level of the esplanade, which is to be paved with marble tiles of approved patterns. The other method of finish proposed, is to fill earth about the present terrace, and extend this filling as far from the monument as to fade the slopes of the embankment gradually into the surrounding surfaces, and this is to be done with so much skill as to give the mound an appearance as far from artificial as possible. This mound is then to be planted with trees and shrubs, and paths are to be laid out. A pavement is to be put around the foot of the mound, far enough to prevent storm waters from washing out the filling. If the marble wall is decided upon, an appropriation of $612,300 is asked to complete the entire work. If the second proposition is adopted but $166,800 is desired. The joint commission favor the latter method.

The Congressional Commission to arrange for the dedication of the monu-

ment invites through the medium of the Associated Press all civil, military and naval organizations in the United States to attend the ceremonies, which will be held at the base of the monument on the 21st of February, 1885. Any organization accepting this invitation is requested to notify Lieutenant-General P. H. Sheridan, U. S. A., Marshal of the day, of the number of persons in such organization, whereupon he will assign it to proper position in the procession to be provided for by the commission. At a meeting of the commission recently the programme was decided upon. The morning is to be devoted by the Marshal of the day to the concentration of societies and troops on the ground. The ceremonies at the monument will begin precisely at 12 o'clock, Senator John Sherman, Chairman of the Congressional Commission, presiding. The programme will be as follows:

Music. Prayer by Rev. Mr. Sutor, of Christ Church, Alexandria, Va. Remarks by W. W. Corcoran, First Vice-President of the Washington Monument Society. Remarks by the engineers of the joint commission turning over the completed structure to the President of the United States. Acceptance by the President for the people of the United States and dedication to the memory of General George Washington. Music.

During the performance of music the procession will be formed and will proceed to the Capitol Grounds where it will be reviewed by the President of the United States.

The order of procession will be as follows:

Chief Marshal, with Chief of Staff and an aide from every State and Territory; military escort; General commanding; brigade of artillery; brigade of infantry; naval brigade; battalion of marines; chartered military organizations, taking precedence by the dates of their charters, and temporarily organized in regiments and brigades; civic procession; Congressional Commission; members and ex-members of the joint commission for the completion of the monument; engineers of the monuement and detail of workmen; the Washington Monument Society; the President of the United States and orator of the day; the President and Vice-President elect of the United States; ex-Presidents of the United States; Judges of the Supreme Court; Diplomatic Corps; Governors of States and their respective staffs, taking precedence in the order of admission of their States into the Union; Senate and House of Representatives; Commissioners of the District of Columbia; Society of the Cincinnati; Masonic fraterntty, with other organizations which officially contributed stores or money for the erection of the monument; citizens of States and Territories, with civic organizations from those States without partisan flags or emblems, each State taking precedence in order of admission into the Union; Fire Department of the District of Columbia and visiting firemen.

BOTANY.

VEGETABLE DISSEMINATION.

REV. L. J. TEMPLIN.

Whoever looks into the vegetable world for the first time with an intelligent eye and a thoughtful and inquiring mind will be forcibly struck with the manifestations of design that meet him on every hand. The wise adaptation of means to ends and the beautiful harmony that appears in all departments of organic nature naturally lead the unbiased mind to the inference that, behind and beneath all this order and harmony, originating, upholding and directing them, there is, and of necessity must be, an all comprehending intelligent power. Probably in all the realm of organic nature there is no more manifest exhibition of wise adaptation of means to the accomplishment of worthy purposes than is seen in the various methods employed for the dispersion and dissemination of the different species of plants. This field of research furnishes so many evidences of design, and so much of variety and excellence that it seems difficult if not impossible to shut out the conviction that some intelligent designer must have been employed in planning a scheme that has so many excellences to commend it to the enlightened judgment. To attribute all this to chance is to invest chance with the attributes and acts of the Deity, and simply changes the name of this great first cause. But in the sense in which this term is generally used the assumption is absurd, as, in that sense chance is nothing and consequently can do nothing. Turning our attention to the subject of the dissemination of plants, we find Nature employing various methods that are not confined to any particular order or class of plants. Considering a plant in its relation to the world at large as well as to its own species, its whole purpose in life seems to be to propagate its own species, and disseminate its progeny as extensively as possible under its surrounding conditions. The spreading of plants from the original locality is accomplished not only in a great variety of ways, but also with a great diversity of degrees of rapidity.

The method by which the offspring is carried the least distance from the parent plant, and, consequently, in which the dissemination is the slowest, seems to find illustrations in those cases in which the young plant starts as a sucker or offshoot directly from the base or collar of the parent plant. In this process adventitious buds are formed at or just beneath the surface of the ground which push up new stems into the air, and from the subterranean parts of these, new roots are sent out into the soil, thus enabling the young plant to draw its nourishment from soil and air independently of the parent plant and even to survive

the death and decay of that parent notwithstanding the vital union that previously existed between them. These in turn form buds and send up suckers, thus further extending the group till joining with other similar groups an extensive break or forest is formed.

Examples of this are exceedingly numerous. This mode is often illustrated by the peach, apple and basswood among trees; the elder, currant and gooseberry among shrubs, and the balm, rhubarb and various grasses among herbaceous plants. A similar or identical principle is involved in those cases in which not only the parts about the base of the plant, but all parts of the roots, even to their extremities, form buds and send up suckers, thus extending the area occupied by the plant much more rapidly than in the preceding case. Of this method the wild plum, murello cherry, and the blackberry and red-raspberry are well known examples. Resembling this method in appearance is the multiplication of plants and the consequent growth of them a short space from the parent plant, is that by means of the rhizoma or underground stem. Some plants send out these stems laterly at a greater or less depth below the surface of the ground. At frequent intervals, greater or less according to the species of plant, a node is formed from which roots are emitted and a stem is sent up to the surface where it forms a perfect, and, to all appearances, an independent plant. Not only does this rhizoma continue to extend, sending up its numerous stems, but from each of its nodes similar stems branch off, usually on both sides, which repeat the same phenomena as the original one. In this way these stems and plants are multiplied till the whole space occupied by this multiple plant becomes a regular net-work of stems and the plants become so crowded as to smother the later comers that are struggling to reach the light and air. A single plant of this nature will, in a comparatively short time, occupy all the ground for a considerable distance in all directions from the original plant. And if it be a perennial, this process will continue from year to year, and there is really no limit to its extension except such as may be presented by insurmountable obstacles that may bar its further progress. As examples of this mode of propagation and dispersion may be mentioned the Canada-thistle, Chufa, Bermuda-grass and couch or quitch-grass.

Tubers, as of the potato and artichoke, are only enlarged underground stems, full of buds that we call eyes. From them the plants of the next season are produced a little distance from the stalk of the parent plant, and so the young plants are gradually separated and dispersed. Similar in nature and manner of growth to the underground creeping plants are those that send their creeping stems on the surface of the soil, sending roots into the soil and stems into the air, and also other creeping stems in lateral directions on the surface. Of this class may be named the twin-flower, the partridge-berry, some species of mint and some of the creeping grasses.

Differing but little from this is the regular running plant that sends out a slender stem that grows to some length without node or leaf; a cluster of leaves is then formed, from the base of which roots enter the ground and thus a complete

plant is formed, while the runner continues its course forming other similar plants as it progresses.

The best illustrations of this mode of dissemination are the strawberry and the cinquefoil. Rising still higher, we find plants with an upright mode of growth, that bend over till their tips come in contact with the soil where they take root and form new plants. In this manner the species travels, making a few feet of progress each year. The hobble-bush and black raspberry are good examples of this mode.

Many trees and plants, when their branches are brought into contact, with moist soil, will take root and produce new plants at a considerable distance from the one to which they are attached. The grape and gooseberry are familiar examples; but nearly all kinds of vegetation will do likewise if the conditions are exactly favorable. Still another method of extending certain vegetable forms is by means of aërial roots that descend from the branches till they come in contact with the soil, which they enter and divide as other roots. The circulation is then reversed and the portion above ground becomes a true stem. The stems continuing to elongate, this process is repeated on all sides till a single tree with its multitude of trunks becomes a forest capable of sheltering an army of men. The Banian tree is the most noted illustration of this. A single tree of this species is known to cover a whole island of considerable extent.

So far we have considered the dispersion of plants only in cases where the young plant remains attached to its parent till it has taken root and become established and capable of existing as an independent plant, but in none of these cases could the offspring start in life at any great distance from the parent plant, from which it proceeded and of which for a time it formed a part, consequently their progress was but slow; at most amounting to but a few feet in a year, and in many cases requiring many years to advance but a very few feet.

But it is evident that it would have required interminable ages to extend any forms of vegetable life, from any center of dispersion, to the different parts of the earth by any of these methods.

Nature has therefore provided for the general dissemination, reproduction and perpetuation of the various species of vegetable forms through the agency of seeds. Seeds are embryonic plants, in which the germ of the future plant, accompanied by a sufficiency of plant-food to sustain it till it becomes able to secure its own nutriment from the soil and air, is wrapped in peculiar cerements and generally enclosed in a leathery, horny or woody covering or shell. These seeds may be carried "to earth's remotest bounds," and preserved for years, and in some cases probably for ages, and then, when placed under favorable conditions, germinate and grow, producing in all essentials an exact counterpart of the plant by which the seed was produced.

The various means to be employed for the dissemination of seeds so as to scatter as far and wide as possible the plants of different species, seems—I speak it reverently—to have received the most careful attention of the Author of nature.

Many seeds and nuts are not provided with any means to aid in their distribution, but this is often accomplished in some degree by the spread of the branches causing them to fall at a little distance from the root of the plant producing them. Nuts and acorns in falling frequently strike on branches and bound or glance off to a distance of some rods. And in falling to the ground they frequently strike on sticks, etc., and bound to a considerable distance, and should it be on a hillside, they may go several rods before stopping.

Many plants and shrubs grow in a leaning or inclined position as if on purpose to reach out and drop their seeds as far as possible from their own roots.

Many grow entirely prostrate, sending out their stems on the surface of the ground, apparently for the same purpose. Scores of plants might be named in illustration of this fact. Some plants have their seed carpels so arranged as to give the appearance of having been made specially to retain instead of disperse the seeds they contain. Poppy, jimson, mullein and many others have the opening at the top as if to prevent the seeds from falling out. But in this we see a wise provision for the scattering of the seed, for if the openings were at the bottom instead of the top the seed as soon as ripe would all fall out around the stalk on which they grew making it impossible to thrive; but as arranged the seed can be thrown out only as the plant is shaken by the wind or other means, and so is scattered around to a considerable distance. The wind is thus seen to become an agent in the dispersion of seeds. The seeds of some trees are furnished with wings (samara) to enable them to float or sail on the air or be carried by the wind as they fall, so they reach the ground some distance from the trees on which they grew. Maple, ash, elm, tulip-tree, linden or basswood, and pine are thus furnished with winged seed. It is worthy of notice that all these are trees that grow to a considerable height so the seeds may sail to a good distance before reaching the ground.

In this connection notice may be taken of the honey-locust and coffee-tree, whose seeds grow in a broad, flat pod, generally with a spiral twist that sometimes causes them to sail off several rods from the parent tree. Every one is acquainted with different kinds of plants that have attached to their seed a tuft of woolly or hairy pappus or down by which they are carried long distances by the wind. It is impossible to assign any limits to the journeys some of these seeds with their buoyant attachments will sometimes travel. Some claim, and with reason, that during long continued storms they may be carried across the ocean and fall on distant continents.

Thistle, dandelion, fire or butter-weed, are well known examples. The seeds of the cottonwood (poplar) are enveloped in a cottony down that causes them to float about and scatter to great distances over the country. He that cannot see adaptation and design in all these arrangments is blind indeed. Other plants, instead of furnishing their seeds with wings and down to fly with and travel from place to place themselves, scatter their seeds by the way. Two or three species of plants grow in this prairie country, that when grown form large bunches and when broken off by the wind they go rolling and tumbling over

the fields and prairies as driven by the wind, veritable "tumbling-weeds," scattering not only their seeds, but often those of other plants that have become entangled in them. The rose of Jericho (Anastatica) that grows in the arid deserts of both Africa and Asia, when mature, rolls up in a ball, becomes detached from the ground and goes rolling before the wind till it reaches a moist spot, or there falls a slight sprinkling of rain, when it immediately unrolls, the pods open and the seeds fall out and germinate within eighteen hours, so that by the time the transient moisture has disappeared the young plant has taken root and is ready to grow in spite of the scorching sun and blasting winds of the desert. While a few plants thus travel and sow their own seeds, others stay at home and throw them so as to scatter them to various distances. Some geraniums when the pod bursts throw their seeds out by a little spring that is arranged in it for that purpose.

In the pods of beans the fiber is arranged at an oblique angle with the linear direction of the pod and when it becomes dry and bursts, this arrangment of the fiber causes the two halves of the pod to suddenly twist spirally, by which motion the seeds are thrown out to some distance. The castor-oil bean also has the habit of throwing its seeds out by a sudden springing of the material of the pod Almost every one has noticed how the parts of the pod of the touch-me-not (im patiens) will curl up with a sudden spring and scatter the seeds in all directions on being touched or shaken. The wild touch-me-not, or jewel-weed, acts in the same manner but with even still greater energy. In cyclanthera, the fruit of which is not symmetrical, one side being flat and the other round, when ripe suddenly explodes scattering its seeds on all sides.

In arcentholium, a relative of the mistletoe, and a parasite of the juniper, the seeds are thrown from one tree to another. The squirting cucumber, a well known plant of southern Europe, as it approaches maturity, becomes so gorged with fluid that when fully ripe it bursts near the place of attachment to the stem and throws its contents to a distance of several yards. The discharge is accompanied by a report as of a toy pistol. Persons venturing to touch one, or even passing near them are liable to be greeted with the contents of this vegetable pop-gun. Many other plants that project their seeds might be named, but these are sufficient for our purpose. Water is also an agent in the dispersion and dissemination of seeds. During heavy rains and floods nearly all kinds of seeds are liable to be carried down from the higher ground into the rivers and by them transported long distances. These eventually find a resting place in the sediment of some island, or low bottom land, and spring up and flourish luxuriantly. The currents of the ocean also become the means of transport for seeds that are adapted to floating. The cocoanut, whose corky shell so well adapts it to this mode of conveyance, has thus been carried to all the islands of the tropics.

In many cases animals are agents in the dispersion of the seeds of plants. Numerous species of trees and plants bear edible seeds and nuts that are gathered by various animals and birds as winter stores, some of which are lost or forgotten and so are left to grow the following year. Many kinds of fruit are eaten by

birds and animals and the seeds either dropped or, being indigestible, are voided with their droppings and spring up and grow, often at long distances from where they originated.

The seeds of a large number of plants are furnished on their outer surface with barbs or hooks by which they adhere to the coats of animals and are thus carried and scattered far and wide over the range of such animals. Some of these barbs and hooks are quite small as in the burdock, sand-bur, beggar-lice, Spanish-needle, etc. But in a few cases they are large and appear quite formidable. The seed pod of the common martynia of our gardens, when dry will sometimes fasten its long curved claws in the skin of an animal, when it is with difficulty that it can rid itself of this terrible "devil's claw."

But the most formidable production of this kind, probably, in the world is a product of South Africa called by botanists, Harpagophyton procumbens. The seeds of this plant are numerously branched, the branches being near an inch long and having numerous stout, sharp, recurved prickles. When once fastened on an animal it is exceedingly difficult to remove. It is said that lions sometimes in trying to remove it from their feet after stepping on it, get it fastened in their mouths and finding it impossible to remove it die a most miserable death.

And here we take leave of our subject, though numberless other examples might be given to illustrate the beautiful adaptation of means to the purpose of covering the globe with the various vegetable productions of the earth. In the presence of such wisdom and goodness let up learn humility and reverence.

CAÑON CITY, COLORADO, December, 1884.

PHILOSOPHY.

RELIGION AND THE DOCTRINE OF EVOLUTION.[1]

FREDERICK TEMPLE, D. D., BISHOP OF EXETER.

The regularity of nature is the first postulate of Science; but it requires the very slightest observation to show us that, along with this regularity, there exists a vast irregularity, which Science can only deal with by exclusion from its province. The world as we see it is full of changes; and these changes, when patiently and perseveringly examined, are found to be subject to invariable, or almost invariable, laws. But the things themselves which thus change are as multifarious as the changes which they undergo. They vary infinitely in quantity, in qualities, in arrangement throughout space, possibly in arrangement throughout time. Take a single substance such, say, as gold. How much gold

1 Abstracted from "The Relations between Religion and Science," by the Lord Bishop of Exeter.

there is in the whole universe, and where it is situated, we not only have no knowledge, but can hardly be said to be on the way to have knowledge. Why its qualities are what they are, and why it alone possesses all these qualities; how long it has existed, and how long it will continue to exist, these questions we are unable to answer. The existence of the many forms of matter, the properties of each form, the distribution of each: all this Science must in the last resort assume.

But I say in the last resort. For it is possible, and Science soon makes it evident that it is true, that some forms of matter grow out of other forms. There are endless combinations. And the growth of new out of old forms is of necessity a sequence, and falls under the law of invariability of sequences, and becomes the subject-matter of science. As in each separate case Science asserts each event of to-day to have followed by a law of invariable sequence on the events of yesterday; the earth has reached the precise point in its orbit now which was determined by the law of gravitation as applied to its motion at the point which it reached a moment ago; the weather of the present hour has come by meteorological laws out of the weather of the last hour; the crops and the flocks now found on the surface of the habitable earth are the necessary outcome of preceding harvests and preceding flocks, and of all that has been done to maintain and increase them; so, too, if we look at the universe as a whole, the present condition of that whole is, if the scientific postulate of invariable sequence be admitted, and in as far as it is admitted, the necessary outcome of its former condition; and all the various forms of matter, whether living or inanimate, must, for the same reason and with the same limitation, be the necessary outcome of preceding forms of matter. This is the foundation of the doctrine of evolution.

Now, stated in this abstract form, this doctrine will be, and indeed if science be admitted at all must be, accepted by everybody. Even the Roman Church, which holds that God is perpetually interfering with the course of nature, either in the interests of religious truth or out of loving kindness to his creatures, yet will acknowledge that the number of such interferences almost disappears in comparison of the countless millions of instances in which there is no reason to believe in any interference at all. And, if we look at the universe as a whole, the general proposition as stated above is quite unaffected by the infinitesimal exception which is to be made by a believer in frequent miracles. But when this proposition is applied in detail it at once introduces the possibility of an entirely new history of the material universe. For this universe, as we see it, is almost entirely made up of composite and not of simple substances. We have been able to analyze all the substances that we know into a comparatively small number of simple elements—some usually solid, some liquid, some gaseous. But these simple elements are rarely found uncombined with others; most of those which we meet with in a pure state have been taken out of combination and reduced to simplicity by human agency. The various metals that we ordinarily use are mostly found in a state of ore, and we do not generally obtain them pure except

by smelting. The air we breathe, though not a compound, is a mixture. The water which is essential to our life is a compound. And, if we pass from inorganic to organic substances, all vegetables and animals are compound, sustained by various articles of food which go to make up their frames. Now, how have these compounds been formed? It is quite possible that some of them, or all of them to some extent, may have been formed from the first. If Science could go back to the beginning of all things, which it obviously can not, it might find the composition already accomplished, and be compelled to start with it as a given fact—a fact as incapable of scientific explanation as the existence of matter at all. But, on the other hand, composition and decomposition is a matter of every-day experience. Our very food could not nourish us except by passing through these processes in our bodies; and by the same processes we prepare much of our food before consuming it. May not Science go back to the time when these processes had not yet begun? May not the starting-point of the history of the universe be a condition in which the simple elements were still uncombined? If Science could go back to the beginning of all things, might we not find all the elements of material things ready indeed for the action of the inherent forces which would presently unite them in an infinite variety of combinations, but as yet still separate from each other? Scattered through enormous regions of space, but drawn together by the force of gravitation; their original heat, whatever it may have been, increased by their mutual collision; made to act chemically on one another by such increase or by subsequent decrease of temperature; perpetually approaching nearer to the forms into which, by the incessant action of the same forces, the present universe has grown—these elements, and the working of the several laws of their own proper nature, may be enough to account scientifically for all the phenomena that we observe. We do not even then get back to regularity. Why these elements, and no others; why in these precise quantities; why so distributed in space; why endowed with these properties: still are questions which Science can not answer, and there seems no reason to expect that any scientific answer will ever be possible. Nay, I know not whether it may not be asserted that the impossibility of answering one at least among these questions is capable of demonstration. For the whole system of things, as far as we know it, depends on the perpetual rotation of the heavenly bodies; and without original irregularity in the distribution of matter no motion of rotation could ever have spontaneously arisen. And, if this irregularity be thus original, Science can give no account of it. Science, therefore, will have to begin with assuming certain facts for which it can never hope to account. But it *may* begin by assuming that, speaking roughly, the universe was always very much what we see it now, and that composition and decomposition have always nearly balanced each other, and that there have been from the beginning the same sun and moon and planets and stars in the sky, the same animals on the earth and in the seas, the same vegetation, the same minerals; and that though there have been incessant changes, and possibly all these changes in one general direction, yet these changes have never amounted to what would furnish a scientific explanation of the form

which matter has assumed. Or, on the other hand, Science *may* assert the possibility of going back to a far earlier condition of our material system; may assert that all the forms of matter have grown up under the action of laws and forces still at work; may take as the initial state of our universe one or many enormous clouds of gaseous matter, and endeavor to trace with more or less exactness how these gradually formed themselves into what we see. Science has lately leaned to the latter alternative. To a believer the alternative may be stated thus: We all distinguish between the original creation of the material world and the history of it ever since. And we have, nay all men have, been accustomed to assign to the original creation a great deal that Science is now disposed to assign to the history. But the distinction between the original creation and the subsequent history would still remain, and forever remain, although the portion assigned to the one may be less, and that assigned to the other larger, than was formerly supposed. However far back Science may be able to push its beginning there still must be behind that beginning the original act of creation—creation not of matter only, but of the various kinds of matter, and of the laws governing all and each of those kinds, and of the distribution of this matter in space.

This application of the abstract doctrine of evolution gives it an enormous and startling expansion—so enormous and so startling that the doctrine itself seems absolutely new. To say that the present grows by regular law out of the past is one thing; to say that it has grown out of a distant past in which as yet the present forms of life upon the earth, the present vegetation, the seas and islands and continents, the very planet itself, the sun and moon, were not yet made—and all this also by regular law—that is quite another thing. And the bearings of this new application of science deserve study.

Now, it seems quite plain that this doctrine of evolution is in no sense whatever antagonistic to the teachings of religion, though it may be, and that we shall have to consider afterward, to the teachings of revelation. Why, then, should religious men, independently of its relation to revelation, shrink from it, as very many unquestionably do? The reason is that, while this doctrine leaves the truth of the existence and supremacy of God exactly where it was, it cuts away, or appears to cut away, some of the main arguments for that truth.

Now, in regard to the arguments whereby we have been accustomed to prove or to corroborate the existence of a Supreme Being, it is plain that, to take these arguments away, or to make it impossible to use them, is not to disprove or take away the truth itself. We find every day instances of men resting their faith in a truth on some grounds which we know to be untenable, and we see what a terrible trial it sometimes is when they find out that this is so, and know not as yet on what other ground they are to take their stand. And some men succumb in the trial, and lose their faith, together with the argument which has hitherto supported it. But the truth still stands, in spite of the failure of some

to keep their belief in it, and in spite of the impossibility of supporting it by the old arguments.

And, when men have become accustomed to rest their belief on new grounds, the loss of the old arguments is never found to be a very serious matter. Belief in revelation has been shaken again and again by this very increase of knowledge. It was unquestionably a dreadful blow to many in the days of Galileo to find that the language of the Bible in regard to the movement of the earth and sun was not scientifically correct. It was a dreadful blow to many in the days of the Reformation to find that they had been misled by what they believed to be an infallible Church.

Such shocks to faith try the mettle of men's moral and spiritual convictions, and they often refuse altogether to hold what they can no longer establish by the arguments which have hitherto been to them the decisive, perhaps the sole decisive, proofs.

And yet, in spite of these shocks, belief in revelation is strong still in men's souls, and is clearly not yet going to quit the world.

But let us go on to consider how far it is true that the arguments which have hitherto been regarded as proving the existence of a Supreme Creator are really affected very gravely by this doctrine of evolution.

The main argument, which at first appears to be thus set aside, is that which is founded on the marks of design, and which is worked out in his own way with marvelous skill by Paley in his "Natural Theology." Paley's argument rests, as is well known, on the evidence of design in created things, and these evidences he chiefly finds in the framework of organized living creatures. He traces with much most interesting detail the many marvelous contrivances by which animals of various kinds are adapted to the circumstances in which they are to live, the mechanism which enables them to obtain their food, to preserve their species, to escape their enemies, to remove discomforts. All nature, thus examined, and particularly all animated nature, seems full of means toward ends, and those ends invariably such as a beneficent Creator might well be supposed to have in view. And while there is undeniably one great objection to his whole argument, namely, that the Creator is represented as an artificer rather than a Creator, as overcoming difficulties which stood in his way rather than as an Almighty Being fashioning things according to his will, yet the argument thus drawn from evidence of design remains exceedingly powerful, and it has always been considered a strong corroboration of the voice within which bids us believe in a God. Now, it certainly seems at first as if this argument were altogether destroyed. If animals were not made as we see them, but evolved by natural law, still more if it appear that their wonderful adaptation to their surroundings is due to the influence of those surroundings, it might seem as if we could no longer speak of design as exhibited in their various organs; the organs, we might say, grow of themselves, some suitable and some unsuitable to the life of the creatures to which they belonged, and the unsuitable have perished and the suitable have survived.

But Paley has supplied the clew to the answer. In his well-known illustra-

tion of the watch picked up on the heath by the passing traveler, he points out that the evidence of design is certainly not lessened if it be found that the watch was so constructed that, in course of time, it produced another watch like itself. He was thinking not of evolution, but of the ordinary production of each generation of animals from the preceding. But his answer can be pushed a step further, and we may with equal justice remark that we should certainly not believe it a proof that the watch had come into existence without design if we found that it produced in course of time not merely another watch but a better. It would become more marvelous than ever if we found provision thus made, not merely for the continuance of the species, but for the perpetual improvement of the species. It is essential to animal life that the animal should be adapted to its circumstances; if, besides provision for such adaptation in each generation, we find provision for still better adaptation in future generations, how can it be said that the evidences of design are diminished? Or take any separate organ, such as the eye. It is impossible not to believe, until it be disproved, that the eye was intended to see with. We cannot say that light was made for the eye, because light subserves many other purposes besides that of enabling eyes to see. But that the eye was intended for light there is so strong a presumption that it cannot easily be rebutted. If, indeed, it could be shown that eyes fulfilled several other functions, or that species of animals which always lived in the dark still had fully-formed eyes, then we might say that the connection between the eye of the animal and the light of heaven was accidental. But the contrary is notoriously the case—so much the case that some philosophers have maintained that the eye was formed by the need for seeing, a statement which I need take no trouble to refute, just as those who make it take no trouble to establish, I will not say its truth, but even its possibility. But the fact, if it be a fact, that the eye was not originally as well adapted to see with as it is now, and that the power of perceiving light and of things in the light grew by degrees, does not show, nor even tend to show, that the eye was not intended for seeing with.

The fact is that the doctrine of evolution does not affect the substance of Paley's argument at all. The marks of design which he has pointed out remain marks of design still, even if we accept the doctrine of evolution to the full. What is touched by this doctrine is not the evidence of design but the mode in which the design was executed. Paley, no doubt, wrote on the supposition (and at that time it was hardly possible to admit any other supposition) that we must take animals to have come into existence very nearly such as we now know them: and his language, on the whole, was adapted to that supposition. But the language would rather need supplementing than changing to make it applicable to the supposition that animals were formed by evolution. In the one case the execution follows the design by the effect of a direct act of creation; in the other case the design is worked out by a slow process. In the one case the Creator made the animals at once such as they now are; in the other case he impressed on certain particles of matter, which, either at the beginning or at some point in the history of his creation, he endowed with life, such inher-

ent powers that in the ordinary course of time living creatures such as the present were developed. The creative power remains the same in either case; the design with which that creative power was exercised remains the same. He did not make the things, we may say; no, but he made them make themselves. And surely this rather adds than draws force from the great argument. It seems in itself something more majestic, something more befitting him to whom a thousand years are as one day and one day as a thousand years, thus to impress his will once for all on his creation, and provide for all its countless variety by this one original impress, than by special acts of creation to be perpetually modifying what he had previously made. It has often been objected to Paley's argument, as I remarked before, that it represents the Almighty rather as an artificer than a creator, a workman dealing with somewhat intractable materials and showing marvelous skill in overcoming difficulties rather than a beneficent Being making all things in accordance with the purposes of his love. But this objection disappears when we put the argument into the shape which the doctrine of evolution demands, and look on the Almighty as creating the original elements of matter, determining their number and their properties, creating the law of gravitation whereby as seems probable the worlds have been formed, creating the various laws of chemical and physical action, by which inorganic substances have been combined, creating above all the law of life, the mysterious law, which plainly contains such wonderful possibilities within itself, and thus providing for the ultimate development of all the many wonders of nature.

What conception of foresight and purpose can rise above that which imagines all history gathered as it were into one original creative act from which the infinite variety of the universe has come and more is coming even yet?

And yet again, it is a common objection to Paley's and similar arguments that, in spite of all the tokens of intelligence and beneficence in the creation, there is so much of the contrary character. How much there is of apparently needless pain and waste! And John Stuart Mill has urged that either we must suppose the Creator wanting in omnipotence or wanting in kindness to have left his creation so imperfect. The answer usually given is that our knowledge is partial, and, could we see the whole, the objection would probably disappear. But what force and clearness are given to this answer by the doctrine of evolution, which tells us that we are looking at a work which is not yet finished, and that the imperfections are a necessary part of a large design the general outliness of which we may already trace out, the ultimate issue of which, with all its details, is still beyond our perception! The imperfections are like the imperfections of a half-completed picture not yet ready to be seen; they are like the bud which will presently be a beautiful flower, or the larva of a beautiful and gorgeous insect; they are like the imperfections in the moral character of a saint who nevertheless is changing from glory to glory.

To the many partial designs which Paley's "Natural Theology" points out, and which still remain what they were, the doctrine of evolution adds the design of a perpetual progress. Things are so arranged that animals are perpetually

better adapted to the life they have to live. The very phrase which we commonly use to sum up Darwin's teaching, the survival of the fittest, implies a perpetual diminution of pain and increase of enjoyment for all creatures that can feel. If they are fitter for their surroundings, most certainly they will find life easier to live. And, as if to mark still more plainly the beneficence of the whole work, the less developed creatures, as we have every reason to believe, are less sensible of pain and pleasure; so that enjoyment appears to grow with the capacity for enjoyment, and suffering diminishes as sensitivity to suffering increases. And there can be no doubt that this is in many ways the tendency of nature. Beasts of prey are diminishing; life is easier for man and easier for all animals that are under his care: many species of animals perish as man fills and subjugates the globe, but those that remain have far greater happiness in their lives. In fact, all the purposes which Paley traces in the formation of living creatures are not only fulfilled by what the Creator has done, but are better fulfilled from age to age. And, though the progress may be exceedingly slow, the nature of the progress cannot be mistaken.

If the "Natural Theology" were now to be written, the stress of the argument would be put on a different place. Instead of insisting wholly or mainly on the wonderful adaptation of means to ends in the structure of living animals and plants, we should look rather to the original properties impressed on matter from the beginning, and on the beneficent consequences that have flowed from those properties. We should dwell on the peculiar properties that must be inherent in the molecules of the original elements to cause such results to follow from their action and re-action on one another. We should dwell on the part played in the universe by the properties of oxygen, the great purifier, and one of the great heat-givers; of carbon, the chief light-giver and heat-giver; of water, the great solvent and the store-house of heat; of the atmosphere and the vapors in it, the protector of the earth which it surrounds. We should trace the beneficent effects of pain and pleasure in their subservience to the purification of life. The marks of a purpose impressed from the first on all creation would be even more visible than ever before.

And we could not overlook the beauty of nature and of all created things as part of that purpose, coming in many cases out of that very survival of the fittest of which Darwin has spoken, and yet a distinct object in itself. For this beauty there is no need in the economy of Nature whatever. The beauty of the starry heavens, which so impressed the mind of Kant that he put it by the side of the moral law as proving the existence of a Creator, is not wanted either for the evolution of the world or for the preservation of living creatures. Our enjoyment of it is a super-added gift certainly not necessary for the existence or the continuance of our species. The beauty of flowers, according to the teaching of the doctrine of evolution, has generally grown out of the need which makes it good for plants to attract insects. The insects carry the pollen from flower to to flower, and thus, as it were mix the breed; and this produces the stronger plants which outlive the competition of the rest. The plants, therefore, which are most

conspicuous gain an advantage by attracting insects most. That successive generations of flowers should thus show brighter and brighter colors is intelligible. But the beauty of flowers is far more than mere conspicuousness of colors, even though that be the main ingredient. Why should the wonderful grace, and delicacy, and harmony of tint be added? Is all this mere chance? Is all this superfluity pervading the whole world and perpetually supplying to the highest of living creatures, and that, too, in a real proportion to his superiority, the most refined and elevating of pleasures, an accident without any purpose at all? If evolution has produced the world such as we see and all its endless beauty, it has bestowed on our own dwelling-place in lavish abundance and in marvelous perfection that on which men spend their substance without stint, that which they value above all but downright necessities, that which they admire beyond all except the law of duty itself. We cannot think that this is not designed, nor that the Artist who produced it was blind to what was coming out of his work.

Once more, the doctrine of evolution restores to the science of nature the unity which we should expect in the creation of God. Paley's argument proved design, but included the possibility of many designers. Not one design, but many separate designs, all no doubt of the same character, but all worked out independently of one another, is the picture that he puts before us. But the doctrine of evolution binds all existing things on earth into one. Every mineral, every plant, every animal has such properties that it benefits other things besides itself, and derives benefit in turn. The insect develops the plant, and the plant the insect; the brute aids in the evolution of the man, and the man in that of the brute. All things are embraced in one great design, beginning with the very creation. He who uses the doctrine of evolution to prove that no intelligence planned the world, is undertaking the self-contradictory task of showing that a great machine has no purpose by tracing in detail the marvelous complexity of its parts, and the still more marvelous precision with which all work together to produce a common result.

To conclude, the doctrine of evolution leaves the argument for an intelligent Creator and Governor of the world stronger than it was before. There is still as much as ever the proof of an intelligent purpose pervading all creation. The difference is, that the execution of that purpose belongs more to the original act of creation, less to acts of government since. There is more divine foresight, there is less divine interposition; and whatever has been taken from the latter has been added to the former.

Some scientific students of nature may fancy they can deduce in the working out of the theory results inconsistent with religious belief; and in a future lecture these will have to be examined; and it is possible that the theory may be so presented as to be inconsistent with the teaching of revelation. But, whatever may be the relation of the doctrine of evolution to revelation, it cannot be said that this doctrine is antagonistic to religion in its essence. The progress of science in this direction will assuredly end in helping men to believe with more assurance than ever that the Lord by wisdom hath founded the earth, by understanding hath he established the heavens.—*Popular Science Monthly.*

ON RAPID CHANGES IN THE HISTORY OF SPECIES.

Mr. Thomas Meehan exhibited flowers of the remarkable *Halesia* noted at page 32, and remarked on the wide divergence reached without any intervening modifications from the original, and observed that it was another illustration of what he thought must now be generally accepted, that the maxim of Ray "*Natura non facit saltum*" itself needed modification. He had called attention to this particular departure, among others, in a paper before the *American Association for the Advancement of Science*, in 1874;[1] what he desired to do now was to emphasize a few of the points brought out prominently in that paper, that "Variations in species as in morphological changes in individuals, are by no means by gradual modifications; that suddenly formed and marked variations perpetuate themselves from seeds, and behave in all respects as acknowledged species; and that variations of similar characters would appear at times in widely separated localities."

In addition to the illustrations given in that paper, a remarkable one was afforded by the *Richardia æthiopica*, the common "calla" of gardens, the present season. Some four inches below the perfect flower a mere spathe was developed, partially green, but mostly white, as usual, but in this case we do not call it a spathe, but a huge bract. In other words, the usually naked flower-scape of the *Richardia* had borne a bract. Flowers with a pair of more or less imperfect spathes were not uncommon in some seasons; the peculiarity of the present season was the interval of several inches on the stem, which justified the term of bract to the lower spathe. From the vicinity of Philadelphia numbers had been brought to him, and others had been sent from Ohio, Indiana and Illinois—some hundreds of miles apart. What was the peculiarity in this season over others which induced the production of this bract, was one question. Whatever it may have been, it operated in bringing about a change of character, without the intervention of seed, directly on the plant, and in many widely separated places at the same time. What is to prevent a law which operates exceptionally in one season, operating again and in a regular and continuous way? So far as we can understand there can be no reason; and, if it should, we have a new species, not springing from a seed, or one individual plant—constituting one geographical centre of creation from which all subsequent descendants emigrated and spread themselves—but a whole brood of new individuals already widely distributed over the earth's surface, and entirely freed from the "struggle for existence" which the developement of a species from a solitary individual pre-supposes.

Aside from the great value of this illustration of how the whole character of a species might be modified simultaneously over a wide extent of country, it afforded a lesson in environment. External circumstances may influence modification, but only in a line already prepared for modification. This must necessarily be so, or change would be but blind accident, whereas palæontology teaches

1 See Proc. Amer. Assoc. Ad. Science, volume xxiii, p. B. 9.

us that change has always been in regular lines, and in co-ordinate directions which no accident has been able to permanently turn aside. Just as in the birth of animals, we find, that however powerful may be some external law of nutrition, which, acting on the primary cell of the individual decides the sex, yet we see that no accident has been able to disturb the proportion of the sexes born, which has always been, so far as we know, nearly equal. So in the birth of species, making all allowances for the operation of environment, the primary plan has been in no serious way disturbed; we have to grant something to environment in the production of new forms, but only as it may aid in innate power of change, ready to expend itself on action as soon as the circumstances favor such development—circumstances which after all have very little ability to determine what direction such change shall take.

We know that distinct forms do spring through single individuals from seed, and that after battling successfully with all the vicissitudes of its surroundings, a new form may succeed in spreading, through the lapse of years or ages, over a considerable district of country. But the idea that always and in all cases species have originated in this manner, presents, occasionally, difficulties which seem insurmountable. In the case of the similarity between the flora of Japan and that of the eastern portion of the United States, we have to assume the existence of a much closer connection between the land over what is now the Pacific Ocean, in comparatively modern times, in order to get a satisfactory idea of the departure of the species from one central spot; and to demand a great number of years for some plants to travel from one central birthplace before the land subsided, carrying back species in geological time further, perhaps, than mere geological facts would be willing to allow. But if we can see our way to a belief that plants may change in a wide district of country simultaneously in one direction, and that these changes once introduced, be able to perpetuate themselves till a new birth-time should arrive, we have great advancement towards simplifying things.—*Proceedings of Philadelphia Academy of Science.*

ASTRONOMY.

SUN AND PLANETS FOR JANUARY, 1885.

W. DAWSON, SPICELAND, IND.

About an hour before New Year's the Sun is in Perigee, its nearest point to the Earth, when its R. A. is 18h. 48m.; and declination 22° 00′ S. Thus it has started northward and the days are growing longer. Spots on the Sun have broken out considerably since their disappearance November 8th. On the 14th of November there were five groups and fifty spots. December 2d four

groups and sixty-six spots. On the the 8th I counted only fourteen spots. The weather has been unfavorable since then—now the 18th.

New Moon occurs January 16th, about 3:00 A. M., and Full Moon on the 30th at 11:00 A. M. The Moon passes over and hides for nearly an hour, the star Theta Libræ, in the morning of January 10th, about 3:00 to 4:00 o'clock. Another phenomenon of considerable interest will occur near 7:00 P. M., January 28th, viz.: the passage of the Moon very near a star (Lambda in Gemini) so that the star will appear to pass very near the south edge of the Moon, and may be actually hid for a few moments. In such a case it may be possible, with a good telescope, to see the star disappear and re-appear alternately among the high mountains on that part of the Moon. Such an observation would, at least, be quite interesting.

Mercury comes to inferior conjunction with the Sun January 3d; and greatest elongation on the 26th, when it will be nearly 25° W. of the Sun, and may be observed as a moving star. Venus is still a Morning Star in the southeast. Mercury will be 1° north of it in the morning of the 24th. Mars is too near the Sun to be visible. Jupiter rises some north of east about 9:00 o'clock January 1st; and at 7:00 o'clock on the 31st. So it will be in good position for observation toward the last of the month. Its four moons may be seen with a spy-glass. Saturn is as well situated for evening observation as it can be. It is considerably below and north of Pleiades, forming a triangle with them and Capella. It is three hours high at 6:00 o'clock January 1st. Its ring and one moon (Titan) can be seen with a good-sized spy-glass. Uranus is nearly between the stars Eta and Gamma of Virgo, just visible to the naked eye when the sky is clear and Moon absent. Neptune is in a starless region of Taurus, about 8° southwest of Pleiades. It is quite invisible to the naked eye, and can only be found by the aid of an equatorial telescope.

NATURAL HISTORY.

ODDITIES OF ANIMAL CHARACTER.

Mr. J. S. Mill, in his essay on "Liberty," long ago warned us against the stupefying influence of custom upon human beings, and held that we ought to encourage eccentricities in each other, and to guard jealously the right to be eccentric, instead of insisting on reducing every one by the hard-and-fast Procrustean standard to a single dead level of mediocrity. But, whatever our sins may be in this respect toward human beings, surely they are greater still toward the domestic animals. We reduce our horses, so far as possible, to the mechanical condition of locomotive engines—indeed, eccentric horses might involve very serious dangers to life and limb—our dogs to sentinels, which we drill to a social

decorum as rigid as our own; while we regard the eccentricities of a cat with undisguised horror, as the mere prelude to dangerous insanity. No one who watches can fail to see how bigoted we are against anything like a "new departure" among our poor relations. If a man begins to save up against his old age, we call it thrift, and praise him as a small capitalist who is giving hostages to fortune; but if a dog accumulates a store of bones or food, we look upon him as indulging in dangerous caprices, which may end in the necessity of putting a bullet through his head. There may be exceptions here and there. Sometimes you will find an old lady who will protect eccentricity in a parrot, a magpie, or a jackdaw, as a bird that has a right to a certain freedom of movements in return for its entertaining attempts at conversation.

But, on the whole, there is no sterner standard of conventionality than that which we enforce on our domestic animals. Pet dogs become perfect bigots in favor of the usual, and persecute any attempt to deviate from it on the part even of a more powerful and less favored colleague, as the Inquisition persecuted heresy, or as the court of Russia persecutes Nihilism. There is nothing equal to the indignation of an in-doors dog at any invasion of the privacy of the drawing-room by an out doors dog, and nothing more melancholy than the servile apologies which the big dog will make to the little one, for even proposing to break through the animal etiquette of the house. The horror of the queen's chamberlain, when once an officer presented himself at the *levee* in the proper court suit diversified by slippers, which he had forgotten to exchange for the regulation boots, was not so great as the horror of the terrier and the Pomeranian when a collie or a setter presents himself on the threshhold of their mistress' sitting-room. We smother the genius of our dogs with our conventionalisms, and stifle the originality of our cats with luxurious bribes. We did, indeed, meet the other day, within the precincts of a great cathedral, with a young cat who was spoken of as "epoch-making"—as likely even to originate a new hegira by the fervor of his genius. But even of his great promise we could gather no articulate account. He was still in the period of early youth, and perhaps was brooding over the designs by which he hoped to transform, in some future day, the world of the cathedral close. But, as a rule, it is certain that we teach our domestic animals as the Cingalese teach their tame elephants, to discourage steadily and effectually everything like eccentricities, whether deliberate or capricious, or assertions of liberty, on the part of their wilder colleagues, and so drill them into our dead level of habit.

What important variations of character, however, might we not promote if we took more pains to foster what a writer of thirty years used to call "the individuality of the individual" among our friends of the lower races! Sir John Lubbock thinks that he has partially taught a poodle to read, but, as a correspondent of ours once suggested, that may be a step in the wrong direction—not a development of the true genius of the dog, but an attempt to merge the genius of the dog in the habits peculiar to man, and likely rather to result in ingrafting an imitative humanity on a totally different kind of capacity. On the other hand,

in his experiments on ants, Sir John Lubbock has gone on the sounder principle of setting the ants problems to solve for themselves—a principle which has resulted in showing that different races of ants have very different resources and that different individuals, even in the same race, show a very different amount of resource in dealing with the same difficulty. This is confirmed by what we know of our more intimate friends among the domestic animals; and surely we should do more to develop their capacity by stimulating them to meet difficulties by their own resources than we can effect by taking their training so completely under our own care. Is it not possible that, as things go, the companionship of man is rather an incubus on the natural genius of the inferior animals than a a help to its development? It is clear that the ants, at least, are more sagacious in proportion as they live more apart from man, and are thrown upon their own resources. The harvesting-ants of Texas and the leaf-cutting and military ants of Nicaragua are far higher in civilization than the ants of the more densely peopled countries of Europe. In proportion as they have a freer scope for their efforts, their social communities appear to be founded on a more advanced intelligence and organization. Is it not possible that we stunt the intelligence of our humbler fellow-creatures by doing so much for them, and permitting them to do so little for themselves?

Certainly there is far too little disposition to allow of eccentricity in the lower animals and for what comes of eccentricity. Half-domesticated birds, however, will occasionally show very remarkable eccentricities, and even appear to be making experiments—though experiments which we should, of course, regard as of a very unscientific kind—in the modification of their own instincts. The present writer knows a pigeon of exceedingly eccentric disposition, not unlike "the single gentleman" in Dickens' "Curiosity Shop" in his habits. He keeps seven pigeon boxes all to himself, and persecutes relentlessly any pigeons which propose to share their dwellings with him. He is as averse to the society even of the gentler sex as was St. Anthony himself in Egyptian deserts. Not a pigeon will he admit within the circle of his sway. And yet, in spite of this resolute and inveterate bachelorhood, this eccentric pigeon is always endeavoring to build nests, and looking out for objects of an egg-like form, which he thinks it possible to hatch. He will accumulate twigs and straws now here, now there, at very great pains and labor. He will coo sometimes to inanimate objects, sometimes to captive birds of another breed, sometimes to a kitten or a dog, or even a flower-pot, with the quaintest and politest antics. He will sit patiently on China-saucers on the mantel-piece of one room, while he accumulates the materials for a nest on the top of a closet in another room. He does not even drive away the possible mother of a family with more zeal than he shows in seeking to be a good father to some imaginary chick which he seems to expect to elicit from a ring-stand or a letter-weight. So for as the writer can judge, he is a pigeon of strong Malthusian views, who hopes to inaugurate a new *regime* which may have the same relation to the ordinary habits of pigeons which the Positivist worship bears to

the other religions of the world. He hopes to foster and cultivate the family and parental idea without any corresponding reality, without any aid from outside, indeed, except an apparatus of external ceremony, which feigns the exististence of a purely ideal mate, and affects to indulge in the expectation of impossible offspring. Doubtless he thinks that there is nothing so good as the courtly attitude of a pigeon toward his mate, especially if there be no mate to justify it; nothing more touching than the patient preparation for offspring and the education of the young, especially if there be no young to complicate the problem of tenderness and foresight, by requiring a real supply of food and attention.

This eccentric pigeon seems to be a solitary thinker of the Comtist kind, who hopes to solve the problem of preserving to the full all the higher instincts of bird-life, without the difficulties involved in supplying those instinct with real objects. If a human thinker can empty religion of its meaning, and yet justify all its forms and sentiments and external rites, and if he is to receive nothing but praise for his achievement, why may we not regard with interest and admiration the effort of an eccentric bird to retain all the ceremonial forms of chivalrous observance and elaborate parental care and patience, without, in fact, complicating the situation by admitting the neighborhood of either wife or child? To our mind, the idiosyncrasies of such a creature as this deserve the most attentive study. Who knows whether we might not find in the world of eccentric instinct all sorts of anticipations of eccentric intellect? Who knows whether we might not find genius and originality in other races of animals which would throw as much light upon the genius and originality of man as the eccentricities of this pigeon seem to throw on the eccentricities of a most active and confident school of modern thought? If John Stuart Mill were right in thinking it a sacred duty not to discourage the milder lunacies of human beings, might we not with equal advantage extend his exhortation, and make it include the duty of protecting the independent development of the idiosyncrasies of bird and beast, in the hope of finding in them some clew to the various oddities and harmless insanities of human thought and action?—*American Field.*

BOOK NOTICES.

SECOND ANNUAL REPORT OF THE BUREAU OF ETHNOLOGY, 1880–81: By J. W. Powell, Director. 8vo., pp. 477. Illustrated. Government Printing Office, 1883.

The first part of this handsome volume consists of an account of the operations of the Bureau for the fiscal year by Major Powell himself, the remainder is devoted to special papers by his assistants, illustrating the methods and researches prosecuted under the direction of the Bureau.

Among these papers are an account by Frank H. Cushing, of the Smithson-

ian Institution, of some peculiar rites studied by him while living with the Zuni Indians of New Mexico, entitled "Zuni Fetiches;" one by Mrs. Erminnie A. Smith, entitled "Myths of the Iroquois;" a third by H. W. Henshaw upon "Animal Carvings from Mounds of the Mississippi River;" "Navajo Silversmiths," by Washington Matthews; "Art in Shell of the Ancient Americans," by Wm. H. Holmes; "Illustrated Catalogue of the Collections obtained from the Indians of New Mexico and Arizona in 1879 and 1880," by James Stevenson.

All of these articles are written by persons who have given careful and critical study to their respective subjects and most of them are very copiously illustrated in the handsomest manner.

The investigations of the Bureau have been conducted systematically and the object has been the definite and logical study of arts, institutions, languages, and opinions, each depending upon, and to some extent inseparable from, the other. As Major Powell well puts it, "The study of the arts is but the collection of curiosities unless the relations between arts, institutions, language and opinions are discovered. The study of institutions leads but to the discovery of curious habits and customs unless the deeper meaning thereof is discovered from arts, languages and opinions. In like manner the study of words unless philologic research is based upon a knowledge of arts, institutions and opinions. So also the study of opinions is but the collection of mythic stories if their true meaning is not ascertained in the history of arts, institutions and languages."

With this view of the subject properly understood, the student of ethnology will not long be regarded by the average person as a mere collector of old pottery, arrow-heads and musty bones, but will soon come to occupy his proper place among scientists.

TRAVELS ON FAITH FROM TRADITION TO REASON: By Robt. C. Adams. 12mo., pp. 238. G. P. Putnam's Sons, New York, 1884. For sale by M. H. Dickinson.

This handsomely printed volume is devoted to an account of the writer's experiences in passing from a supposed religious state, through all the phases of doubt and unsettlement, to that of rank infidelity. He is the son of a Presbyterian minister and was brought up by a Christian mother, being taught, as all New England children were in those days, the stern theology of the "shorter catechism" and other Calvinistic doctrines. With such a foundation it is surprising how soon he began to doubt, and more surpsising upon what meagre quibbles his doubts depended. He became a sea captain and having much leisure time on his hands, devoted it to studying the Bible and theological books. He attended church when on land, and apparently earnestly sought to be a Christian and lead a Christian life. Nevertheless his hold upon religion was too slight to bind him and he drifted farther and farther from the teachings of his youth until he actually became a "pagan" of the Bob Ingersoll type, satisfied with being

able to ridicule the Bible and religion by selecting passages separated from context and general plan and holding them up as expository of God's purposes and disposition.

This conception of religion, despite all his teachings and studies, is inconceivably narrow and shallow, never rising to the comprehensiveness necessary to take in anything more than details which are mistaken for principles and failing to grasp the full range and scope of the Bible or to obtain a full grasp of the principles involved. He is almost equally deficient in his understanding of the theories of evolution, which he says gave him "a reasonable conception of the universe and seemed to put solid ground" under his feet. The whole work is a marked instance of what misguided study and misdirected energy, together with restless and unsatisfied nervous temperament, will lead one to in any branch of study.

It is a book which would do serious harm in a school library if read by the children, but which may be perused with impunity by any mature person of well balanced mind.

PRIMARY HISTORY OF THE UNITED STATES: By Edward S. Ellis. 12mo., pp. 224. Van Antwerp, Bragg & Co., Cincinnati, 1884. For sale by M. H. Dickinson.

This little work belongs to the eclectic educational series published by the above named firm, and is a credit to them in point of paper, printing and illustrations. Nothing is more noticeable even to middle-aged persons than the great improvement made within their memories, in school books, both in matter and appearance.

The author has of course attempted to do no more than to chronicle in simple language only the most important events, explain the causes of national movements, and point out the wonderful progress of the United States in everything that makes up a nation. The review questions appended to each chapter are valuable aids to the pupil in indicating memorable points and fixing them in his mind. Such school books deserve a place in all good schools.

REPORT OF AN ARCHÆOLOGICAL TOUR IN MEXICO IN 1881: By A. F. Bandelier. 8vo., pp. 326. Illustrated. Cupples, Upham & Co., Boston, 1884.

This is the second volume of archæological papers published by the Archæological Institute of America, whose president is Charles Eliot Norton and whose secretary is E. H. Greenleaf. The author calls his work an archæological reconnoisance into Mexico, and divides it into four chapters, viz: From Tampico to the City of Mexico; Notes about the City of Mexico; Studies about Cholula and its vicinity; An Excursion to Mitla.

There are twenty-six plates, most of them heliotypes, with hundreds of figures

and illustrations in the text. Many of these are from drawings by the author and the remainder from photographs.

Mr. Bandelier has been employed for several years past by the Institute, first in New Mexico where he studied the Pueblos, and afterwards in Old Mexico where he has devoted himself to the interesting ruins of that country. He is a graceful and interesting writer and an explorer who knows what to look for and how to investigate it, which is more than can be said of all explorers. The subject, though old, is ever attractive, and though Humboldt and LePlongeon, Bancroft and Charnay, besides numerous Spanish, French and Italian explorers, have described these wonderful ruins over and over for several centuries past, this new story of their mystery and grandeur will be read with renewed and undiminished interest.

The Institute has put it forth in handsome style, through its publishers, and can supply any demand upon application to Mr. Greenleaf.

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA, MAY TO OCTOBER, 1884. Edited by Edward J. Nolan, M. D. 8vo., pp. 144. 1884.

The promptness with which this volume has been produced, so unusual with scientific bureaus and societies, is worthy of all commendation. Its contents are, as heretofore, highly attractive from their originality and the nature of most of the subjects discussed. We find among the contributors the names of Professors Leidy, Meehan, Gill, Lewis, Doctors Foote and Brinton, Rev. H. C. McCook and several others less well known in the West. Among the, to us, more interesting papers we note that upon Rapid Changes in the History of Species, by Prof. Thomas Meehan; Rev. Mr. McCook's articles upon the Habits of Spiders, and that of Dr. D. G. Brinton upon "The so-called Bird-Track Rock Sculptures of Ohio." Other papers will commend themselves to other readers who are interested in biology, botany, geology, physiology, etc.

No society of the kind in this country does more original or better work than this.

OTHER PUBLICATIONS RECEIVED.

Signal Service Notes, No. XVI: The Effect of Wind Currents on Rainfall, by G. E. Curtis, U. S. Government Printing Office. Humboldt Library, Double Number, 30cts., No. 62—The Religions of the Ancient World, including Egypt, Assyria, Babylonia, etc., by Rawlinson, M. A., published by J. Fitzgerald, N. Y. A Manual of Geology, with classification tables, by Prof. S. H. Trowbridge; published by National School Furnishing Co., Chicago Ill. Oxygen and Ozone: Their Applications, by Prof. Anton Stamm; published at Leadville, Colo. A Spectro-Photometric Study of Pigments, by Edward L. Nichols, Ph. D. Bul-

letin of U. S. Geological Survey No. 9, Government Printing office. Economic Tracts No. 14: The Competitive Test, by Edward Shepherd; published by Society for Political Education, New York. Humboldt Library No. 60—The Childhood of the World: An Account of Man in Early Times, by Edward Clodd, F. R. A. S., price 15cts; Fitzgerald, publisher, New York. Questions of the Day, No. 13: Public Relief and Private Charity, by Josephine Shaw Lowell, price 40cts; G. P. Putman's Sons, New York. Humboldt Library, No. 61, price 15cts: Miscellaneous Essays, by Richard A. Proctor; Fitzgerald, publisher, New York. Annals of Mathematics, by Ulmund Stone and M. Thornton, Vol. 1, No. 3, Charlottesville, Va. The Song Friend, Vol. 5, No. 12; published by W. S. Staub, Chicago, $1.00 a year. Professional Papers of Signal Service, No. 14: Charts of Relative Storm Frequency for a portion of the Northern Hemisphere, by John P. Finley, Government Printing Office. Economic Tracts, No. 15, The Standard Dollar, by H. W. Richardson, N. Y. U. S. Consular Reports: Reports of Consuls of U. S. on Commerce, Manufacture, etc., of their Consular Districts, No. 45, Government Printing Office.

SCIENTIFIC MISCELLANY.

RECENTLY PATENTED IMPROVEMENTS.

J. C. HIGDON, M. E., KANSAS CITY, MO.

COMBINED CUFF-HOLDER AND SLEEVE-SUPPORT.—This invention relates to that class of devices in which the cuff is supported by spring clamping-jaws, and it consists of an S-shaped strip of metal that is so combined with a suitable pin as to be adapted for fixture within a coat-sleeve, where, by reason of its spring-jaws it will hold the cuff securely in place.

By dispensing with the pin, however, the strip of metal becomes simply a support for the wristlet of the sleeve, and it is applied by placing it upon the edge of the cuff, in which position it is held by reason of its inherent spring power. Now upon the entrance of the descending wristlet within the cuff, it comes in contact with the inwardly-projecting arm of the instrument and is thereby prevented from falling so low as to be exhibited upon the wrist.

In construction, a suitable piece of metal being provided, it is bent at one-third its length or doubled toward its main position to form the two clamping-arms and in an opposite direction to form the supporting-arm. The pin may then be, or may not be, attached as desired.

ELECTRICAL GAME-INDICATOR FOR POOL TABLES.—This improvement provides an efficient indicator whereby the person in charge of a number of tables is

instantly made aware of the beginning of a game and of the particular table upon which it is in progress.

The apparatus consists mainly in constructing both the spot and the triangle of metal, and of placing them in electrical communication with a suitable indicating dial.

The improved metal spot is preferably constructed with a shoulder near its upper end for forming a bearing when it is let down level with the upper surface of the table. A pin or dowel is provided upon its lower extremity in the form of a binding screw to which the circuit-wire is attached. The spot is perfectly insulated in its position upon the table.

In operation, a battery and an indicating dial are located at such a point in the room as will be convenient for inspection, the spot and the tri-angle are connected by suitable wires to the battery and to the dial. Whenever the table is idle the tri-angle is of course removed from the spot, but, when a game is commenced, the tri-angle is placed in position upon the table in contact with the metal spot, the circuit is thus closed and the fact is indicated by the dial.

THOUGHTS ON SCIENCE TEACHING.

ALEXANDER WINCHELL.

The so-called "inductive sciences" are by no means exclusively inductive. Nor can all science teaching be conducted exclusively by observational methods. On these two points much erroneous doctrine has been inculcated. Aside from certain rational principles which regulate all intellectual processes, it may be said that the so-called inductive sciences begin by induction, and are founded on facts of observation. The knowledge of the facts is the condition of the existence of the science. The facts, while not constitutive of science, are the data of science; and in a process of education they must be acquired. A real portion of the science consists of the body of generalizations based on the facts. Any real knowledge of the science must grasp these principles. But the body of propositions generalized from the data of science may next be employed as grounds of deductive inference. Only thus does science attain to a knowledge of facts inaccessible to observation. Thus science becomes a seer, and her vision penetrates beyond the limited range which bounds the ken of the human race. It is only by deduction from generalized principles that geology, for instance, can venture any affirmation concerning the history of the world in the ages before human observation, or can predict vicissitudes impending in the remote future. Those portions of a science reasoned out from general principles often constitute its most important domain. They generally afford the most entertaining and inspiring themes for contemplation, and this is evidently because the method carries us through time and space and causation to distances most remote from the little circle which limits the sphere of facts merely observed.

We are thus reminded that the subject matter of science, aside from the transcendental concepts and cognitions which are always implied, consists of: 1. Facts of observation. 2. Principles generalized from the facts. 3. Other facts deduced from those principles.

Here are three different kinds of knowable materials to be dealt with by the teacher of science. As to the facts, it scarcely needs to be said that the most effective method of imparting a knowledge of them to others is the *observational.* If the facts of science are to be learned, the best way is to bring the facts and the learner together. The method of the Kindergarten, the laboratory and the field is truly the most efficient and the most agreeable. Too much can not be said of the importance of giving full exercise to the percipient faculties, within all the range where their activity is possible. But next, if direct observation is impossible, the *pictorial* method is the best substitute, provided the pictures are intelligible and correct. Poor pictures are misleading and a weariness. But if these are not available in imparting a cognition of the facts, we must employ the *descriptive* method. Here everything depends on the clearness of the describer's conception of the thing, and the power of the learner to picture mentally the thing described. These are powers of the imagination. Their exercise by the teacher gives vividness, reality and clearness to the fact set forth. Their exercise by the learner gives vividness of conception which is the next thing to visual perception. In the description of objects of natural history, some describers, with the object before them, can not phrase a description out of which a picture could be formed. Some who read the most accurate and vivid descriptions have no power to render them in a clear mental picture. Hence the descriptive method as a dernier resort, is neither to be employed undiscriminatingly, nor condemned unconditionally.

Next, as to the generalizations, the *ratiocinative* process of acquisition should be promoted in all cases; but where the powers of the learner are incapable of seizing the generalization, it must be enunciated *dogmatically.* The generalization is the first attainable constituent of the science. It is of pre-eminent importance, and is imagined by some to be the only genuine scientific material. It is well if the pupil can view the facts under such a presentation as to draw the inference for himself. But the inference must come into his possession, if only received on the authority of the teacher.

As to the deductive materials of science, they presume the existence of generalized principles, and their acquisition by one of the two methods just indicated. The deductive inferences from them should be drawn by the unaided action of the learner's intelligence, where the process is not too recondite. More frepuently, however, the learner can do no better than to listen to the detail of inferences drawn by a teacher of adequate knowledge, reflection, and power of statement. The teaching is either *ratiocinative* or *dogmatic.*

The data and principles of science and of teaching, thus recalled to mind, reveal, manifestly, a certain range of scientific knowledge which may be approached by the observational method, and should be so approached. The acquisition of all which remains must be left to the action of the learner's ratiocin-

ative powers, or, more frequently, to the dogmatic enunciations of the teacher. This discrimination cannot possibly be ignored. To insist that all scientific acquisition shall be by the observational method, is to betray ignorance of the material of science. The most important, the most real and the only fundamental part of science is accessible only to rational perception, not to sensible perception. To denounce the didactic or descriptive presentation of facts is to assume that all facts can be brought before the sense of the learner, and this is a baseless assumption. To denounce all dogmatic statement of general principles, is to assume that the tottering intellect of the young learner is capable of drawing the same generalizations as have been framed by the sturdiest efforts of experts, and this is a baseless assumption. To denounce all dogmatic statement of deductive inferences is to confess inability to perceive the cogency of *a priori* evidence, and thus abdicate the privilege of passing judgment on it; or, if the validity of deductive science is admitted, it is to assume that the learner is already capable of taking, unsupported, the loftiest flights of scientific speculation—a consequence, the very mention of which annihilates the assumption. There must be sometimes a descriptive statement of facts. There must be a dogmatic delivery of inductive doctrines. There must be, unless we would have our teaching grossly defective, a frequent dogmatic exposition of the necessary consequences of established principles.

Finally, as to the times and circumstances under which these various methods of teaching may be employed, we have a few words to offer. Let us first consider the learner of tender years. It requires no argument to make it appear that the generalized and deductive principles of science are not appropriate, or, in any event, are less appropriate, than the facts, to the active percipient powers and the late awakened reflective powers of the young. It seems, however, to require argument to establish the belief in the minds of educators, that the learning of the facts of science is positively suitable to the faculties and aptitudes of the young. If the proposition were accepted, we should not see children and youths shut up for years to the abstractions of arithmetic and grammar, the sporofic and comparatively unproductive details of historical names and dates, or the meaningless and profitless lists of capes and headlands along some remote barbaric shore. We are not denying the usefulness of these things, nor even their comparative usefulness. We strongly feel, however, that during the stage of childish perceptivity, there is greater appropriateness and productiveness in the exercise of the faculties upon facts of present interest, and which actually enter into the organization of sciences of transcendent influence and importance. But, whatever finally may be agreed as to the propriety of introducing the natural sciences to the attention of the child, it can hardly be denied that the most rational method of doing this is to bring the child into contact with the facts, and leave his own mind, as far as it is able, to draw the general inferences to which the facts point. It follows that books and teachers which aim at a systematic, synthetic presentation of one of the natural sciences, forget the order of development of mental faculties, and prepare to leave a sense of weariness and disgust where there

might be a feeling of interest and delight. The only rational procedure with the child, in the study of rudimentary geology, for instance, is, therefore, to take him into the field and permit his faculties of observation and thought to lead him, by the natural processes of investigation and discovery, to the apprehension of those principles which constitute the inductive department of the science. His own faculties then are active, and to some extent, in all cases, the principles reached are principles discovered; the child feels a consciousness of success—a pride in it, an exhilaration over it, and the whole exercise is a delight.

If the case be that of a person entering on a thorough course of scientific study, then equally, an examination of the facts which constitute the data of the science is the first thing in natural order. This is the nature of the study in an elementary course, whether the pupil be a child in the grammar school or a senior in college. But the style of the presentation will vary with the maturity of the learner, and so will the prompting needed in drawing the appropriate lessons from the facts. It is a needlessly prosaic, heavy and deadening process to start a course in science with the conning and memorizing of abstract general statements which rest on no evidence visible to the learner, and sustain no recognized relation to any body of knowledge which interests and inspires, and lifts up the mind. With all the inspiration which belongs to science, it is easy to give it a cold and soporific presentation to the beginner. The order of ideas in the historic development of a science is nature's order in the development of the same ideas in the individual mind. What is most natural is most pleasant and most profitable.

As the study of the science proceeds, the student's mind is prepared for the reception of the higher generalizations, and the far-reaching results of deductive reasoning. The skillful teacher will cause the data to pass before the learner's mind in such order as to prompt the mind, through its own energy, to reach these inferences as original discoveries. That is the best teaching, and those are the best text books, which secure the most of this productive spontaneity. But, as before stated, much must always be enunciated by authority. Especially, while the person continues in the relation of pupil rather than independent investigator, will it remain appropriate and best for the teacher in his own language and way, to enlarge upon the far-reaching consequences of those modes of being and action which are expressed in the higher generalizations of science. To trace those consequences leads the learner's thoughts and imagination into realms so remote from present experience that novelty and wonder lend new incentives to attention and add exalted interest to the conceptions of the science. These higher generalizations and loftier deductions are a grand sequel to the earlier details of facts and the later formulation of doctrines, and they may advantageously be reserved for formal lecture presentation.

There are still other circumstances in which every teacher of science is liable to find himself sometimes placed. Multitudes of persons who cannot or will not pursue any thorough course of scientific study, still desire a knowledge of the grand results of science. This, indeed, is all which the world at large cares for.

It is in truth all which enters into the cultural influence which science exerts upon the intelligence of the masses. Now, as has been shown, this class of scientific knowledge, to those who have not reasoned up to it from the facts, must necessarily be imparted by means of dogmatic statements, and the learner must rest content with the results, ignorant, largely, of the data from which they have been reached. This may be half-knowledge, but beyond question, it may be very interesting and very valuable knowledge. This is the department of scientific knowledge best suited for impartation through popular lectures. It is the aspect of science to which the popular intelligence always turns with eagerness. Still, it is not to be supposed that the highest appreciation requires the exclusion of all statements of fact. The mind—even the popular mind—takes delight in its own activity. It likes to trace the relations of causality by means inductive and deductive. The lecturer, for instance, may direct the attention of his hearers to the familiar phenomena of erosion, occurring within the narrow sphere of his own observation. The hearer will easily follow the generalization of this action into a universal phenomenon; and then, by a mental process equally agreeable, he will accompany the lecturer in a delineation of the ulterior consequences of such geological action. The experimental sciences afford superior opportunities for conducting the hearer over the steps of fact, generalization and deduction. But to assume that no popular instruction in science is legitimate which does not accompany every conclusion by its appropriate proof, is the affectation of a mind which has been running in a rut. To summarize results, we may say that instruction in natural science intended for youthful learners, should deal chiefly with the concrete data, giving occasional glimpses of the ratiocinative procedures to be based on them. Definitions and general enunciations should come at the end instead of the beginning. This work compasses the rudiments of the science. For all persons entering on a thorough course, a similar method should be pursued, extending the range of logical inferences as knowledge accumulates, or the maturity of the learner is more advanced. The inductive method may well be supplemented by formal, descriptive, didactic and dogmatic presentations.

This instruction may cover the fundamental facts and doctrines, and the prominent theories in the science. It embraces the elements of the subject, and ought always to be acquired during the preparation for college. The third phase of scientific teaching, which may be noted as collegiate, should combine the same method with a larger supplement of lectures designed to gather into a unity, with a clearer co-ordination of parts, the somewhat disjointed results of observational and inductive study, and to lead the learners mind over the lofty ranges of remoter generalization, and ulterior results of the causes in action. A fourth form of presentation is the popular, in which the interest and profit of the learner require a minimum of facts and a maximum of general conceptions. Thus the method of instruction in natural science is not one and uniform. It must vary with the subject matter and with the age and aims of the learner. It may be rudimentary, preparatory, collegiate or popular, and in each case a different pro-

portion of the concrete and reflective constituents of science must be presented to the mind.—*Fortnightly Index.*

THE NATIONAL EXHIBIT AT THE NEW ORLEANS EXPOSITION.

In addition to the grant of $1,000,000 made by Congress as a loan to further the project of a World's Fair, and Cotton Centennial in New Orleans, an appropriation of $300,000 was made to enable the various departments of the national Government that are depositories of the nation's historic and industrial annals to make a fitting display. The most imposing and valuable exhibits will be made by the various bureaus comprised in the interior department, represented by Hon. Benjamin Butterworth, commissioner of patents. The manner with which the preparation and arrangement of the vast exhibits of the various bureaus have progressed insures a display that will appropriately and fully place the industrial life and immense mineral wealth of the country before the world.

The bureaus under the department of the interior which will contribute to the exhibit opened on December 16, 1884, are the Patent Office, General Land Office, Bureau of Education, Census Office, United Sttates Geological Survey (which includes the Bureau of Ethnology), and the Office of the Commissioner of Railroads. These exhibits will be ready for shipment to New Orleans in a few days. They will illustrate in a comprehensive manner all the important industries and interests in the United States.

The Bureau of Education will present in school architecture, models and drawings of schoolhouse structures, from the most primitive times up to the most improved building of the present day. Photographs and photo-lithographs will supplement the models and form a considerable part of the exhibit. The fixtures of the school-room, such as are used for heating, ventilation, and the modification of heat and light will be presented. The kindergarten will be shown with all the material which is used in that kind of a school, and a considerable amount of children's work. It is intended that this section shall be under the immediate supervision of an experienced teacher of kindergarten, and that much pains will be taken, not only with the kindergarten itself, but with the material for the instruction of young children.

Primary, grammar, and high school rooms will be fitted up with desks, apparatus, charts, maps, specimens of scholars' work, text-books, and any other material that may fairly represent the appliances found in our best schools. The college rooms will be similarly fitted up, and will be made to display, so far as possible, the contributions of colleges to the bureau for use in this connection.

Professional education, especially the teaching of medicine and dentistry, will be amply illustrated by charts, photographs, and plans of medical buildings; by the instruments used in the profession, and in such other ways as the ingenuity of the medical profession may suggest. The schools of science and technology are expected to contribute largely of their products to the section especi-

ally devoted to institutions of this character. Plans of bridges, buildings, and machines, and constructions of various kinds will form a part of the display of the schools of technology. The schools for the education of the deaf mutes and the blind and reform schools are to be especially represented by their products, coming not only from their school-room, but also from the shops which are frequently a part of these schools. A library room has been planned in which there will be found current numbers of the educational periodicals of the country; the most useful books for teachers; the various city, State, and national reports on education; specimens of foreign reports and periodicals, and other material of a similar nature.

The representation of statistics by charts will be largely shown in this room; the statistics of illiteracy will be presented by colored maps, showing the localities in which education has been most neglected. Physical and chemical laboratories have been planned by professors of these subjects, and will be so arranged as not only to display the apparatus illustrating the different departments of these sciences, but to show visitors some of the more common and useful experiments which are performed before classes in physics and chemistry. The manual training schools which have sprung up in the country since the centennial will be represented by the tools and machines which are used in these schools, and it is believed that under the management of a skillful superintendent the actual operation of these schools in teaching carpentering, forging, machine work, and the like, will be handsomely displayed. The schools of art of the country will be represented by their product, which will form a most interesting part of this display. It is believed that this bureau will make a most interesting and instructive exhibit to all who feel an interest in a more advanced stage of education.

The Census Office will illustrate by a series of illuminated charts and diagrams, together with some geometrical figures, the present stature of this country, and its growth by decades, as far as may be possible, in population, agriculture, manufactures, mining, forestry, fisheries, and other material interests. The present standing of the United States, as compared with foreign countries, will be indicated by a combination of figures and illustrations showing our relative population, industrial employments, and value of products, acreage and agricultural products, wealth, taxation, and indebtedness, with interesting comparative data relating to the defective and dependent classes of the people to their social progress, occupations, etc.

The Geological Survey comprises also the bureau of ethnology. During the last five years this bureau has made large collections of the products of aboriginal art, both ancient and modern, such as textile fabrics, pottery, implements of war and of the chase, with other curious objects, many of which were used in their periodical ceremonies and dances; these latter will be arranged by Mr. Frank Cushing, who is familiar with the mystic rites of these people, and will make an interesting exhibit. Col. James Stevenson has been in the far west during the past two or three months collecting important additions to these ex-

hibits, all of which will be displayed in the National Museum after the close of the exposition.

Among other objects of interest and wonder will be the series of models of the towns of the existing Pueblo tribes, and of the ruins, cliff-dwellings, and towns of the pre-historic peoples. An entirely new series of these has been made on a scale of one-sixtieth—large enough to show much of the interesting details of their architecture and habits of life. The model of the Pueblo of Zuni, the largest, is upward of twenty feet long. Appended to this display will be a number of models of the mounds, earthworks, etc., of the mound-builders. A series of the relics of stone, clay, metal, various tools and implements, and a representation of the skeletons obtained from the mounds. This branch of the work is under the special supervision of Prof. Cyrus Thomas, who has been engaged during the past four or five years investigating the origin and possible history of these unknown people.

The Geological Survey will furnish a number of models of the more important geologic and typographic features of the far west,—the Grand Cañon of the Colorado, the Yellowstone Park, the Yosemite Valley, and the grand district of the Rocky Mountains. There will also be a number of models of the great mines of Colorado, Nevada, and California.

A fine collection of the largest and most elegant photographs ever made will be shown by the transparencies, and will be an exceedingly attractive feature of the exposition. There will be 150 of these pictures which will illustrate chiefly the people and scenery of the far west. They will be returned to the National Museum after the close of the exposition.

There will also be sent from the United States Geological Survey specimens representing the ancient life of the globe, the fishes and reptiles of strange form, some of them of immense size, the multitude of remarkable quadrupeds which have become extinct, the infinitely varied forms of shell fish which have inhabited the seas of former geological periods, and remains of the mighty forest trees that once covered a large portion of the earth's surface, and which have been succeeded by those which now decorate the earth. This exhibit will include minerals of nearly every kind known to science, from the beautiful and costly gem to the common clay of the potter; ores of every metal known to human industry, representations of the mines whose wealth is fabulous, maps and charts showing the location of all this natural wealth, the extent and methods of its development, and giving plain indications of their future productiveness.

The space required for the exhibits of the interior department is as follows: For the Patent Office, 15,650 square feet floor and 1,800 feet wall space. Geological Survey, 10,000 square feet floor and about 1,500 wall space. Pension Office, 600 feet floor and seventy-five feet wall. General Land Office, 300 feet floor and 1,400 feet wall. Commissioner of Railroads, 2,000 feet wall space and floor space to view exhibits. Census Office, 300 feet wall and floor space to view exhibits. The total floor space required is 35,000 square feet.

THE NICARAGUA CANAL.

The President's announcement in his message that a treaty with the Nicaraguan government, which authorizes this government to build, maintain, and forever control a canal, railroad, and telegraph lines across that country, has already been concluded must be both surprising and gratifying to the commercial world. It is a surprise because the negotiations have been conducted to success before any one knew they were being pressed, and gratifying because no more important diplomatic enterprise could have been undertaken than that which has now successfully prepared the way for a water connection between the rich territory of the Pacific slope and the great parts of the Atlantic. From other points of view also the matter is one of great import to the nation.

One hundred miles of the projected enterprise may be reported as almost completed, as it is furnished by the San Juan river and Lake Nicaragua, which is forty miles wide and sufficiently deep for the purpose. The engineering difficulties to be overcome in the remaining fifty-three miles are not great. When this treaty is ratified the Panama question will cease to demand attention—if indeed it shall remain a question.

EDITORIAL NOTES.

THIS number of the REVIEW, like that of December, is conspicuous for its large number of articles by Western contributors. It is also in our opinion exceptionally good in the articles selected from other magazines. The ground covered by these articles is sufficiently wide to meet the wants and sufficiently popular to attract interest, and benefit almost all classes of readers.

We call particular attention to our offers to clubs, and also to the inducements we offer subscribers who desire to subscribe for other magazines.

THE great industries of America form the subject of a series of articles which will commence in the January number of *Harper's Magazine*, with a paper entitled "A Pair of Shoes," written by Howard Mudge Neuhall, a leading shoe manufacturer in Lynn. These industrial articles are planned to give, in readable fashion, a clear idea of how the important articles of industry are made, who make them, how much they earn, and how they live; in short, to inform Americans how they are clothed, fed, and otherwise served in these days of machinery, and how their fellow-Americans earn their respective livings.

WE have received from the author a copy of a new and interesting archæological work entitled "The Book of Algoonah," which attempts to throw fresh light upon the cloudy subject of the Mound-builders. We shall notice it fully in our next number, and in the meantime call attention to the advertisement of the work in this issue.

ITEMS FROM PERIODICALS.

THE January number of the *North American Review* is an excellent one. It presents no very famous names among its contributors,

but it offers a wide variety of unusually readable articles. We are now so safely over the crisis of the presidential election that men of all parties can consider calmly Bishop Huntington's essay on "Vituperation in Politics," and it is to be hoped that what they learn from it will not be forgotten four years hence. Under the title, "The Reunited South," Henry Watterson presents with great clearness the Southern and Democratic view of the political situation as it now stands. This also is extremely interesting to every citizen, whether he agrees with Mr. Watterson or not. Another question of universal concern, which some think will soon make itself a national issue, is that of labor and its compensation; and Col. Hinton, in "American Labor Organizations," shows with what equipment it will take the field. But the article that the literary reader will first turn to is Frederic Harrison's brilliant and incisive discussion of "Froude's Life of Carlyle;" while the religious or philosophical reader will find in Courtney's "Socrates. Buddha, and Christ," specific statements and quotations of those parallel doctrines that are so often vaguely alluded to. For the scientific reader, Mr. Proctor discusses learnedly "Herschel's Star Surveys," and Prof. Le Conte presents and explains some curious facts in relation to "The Evidence of the Senses." Mr. Mulhall's paper on "The Increase of Wealth" is a successful endeavor to render large masses of figures popularly intelligible.

For some months past prospectors have been at work on a coal shaft at St. Joseph, Missouri, having sunk it to the depth of nearly 1,200 feet. As we learn from the *Gazette*, they are now in a dark, oil-bearing sandstone formation and expect to strike oil or coal very soon. All the strata pierced have been found to correspond with those in the coal shaft at Leavenworth, though much thicker. So that the borers expect to find at about 1,235 feet the same vein of coal that has been so profitably worked in the former city at less than 800 feet.

The *Atlantic Monthly* for January, 1885, starts off with a decidedly interesting table of contents: The Prophet of the Great Smoky Mountains, I, Charles Egbert Craddock. A Canadian Folk-Song, William Wilfred Campbell. Childhood in Greek and Roman Literature, H. E. Scudder. The H Malady in England, Richard Grant White. A Marsh Island, I.-III, Sarah Orne Jewett. The Christ of the Snows—A Norwegian Legend, S. Weir Mitchell. A Salem Dame-School, Eleanor Putnam. A Story of Assisted Fate, Frank R. Stockton. Madame Mohl, her Salon and her Friends—First Paper, Kathleen O'Meara. Winter Days, Extracts from the Journal of Henry D. Thoreau. A Country Gentleman, I.-III, M. O. W. Oliphant. The Star in the East, Harriet Prescott Spofford. The New Portfolio, Oliver Wendell Holmes. Vedder's Drawings for Omar Khayum's Rubáiyàt. Culture of the Old School. Recent American Fiction. Studies of the Renaissance. The Contributors' Club. Books of the Month.

The *Popular Science Monthly* presents the following table of contents for January: A Glance at the Jury System, C. H. Stephens. Agnostic Metaphysics, Frederic Harrison. Last Words About Agnosticism, Herbert Spencer. Influences Determining Sex, Prof. W. K. Brooks. My Schools and Schoolmasters, Prof. John Tyndall. Gladiators of the Sea, Frederik A. Fernald (Illustrated). Studying in Germany, Prof. Horace M. Kennedy. State Usurpation of Parental Functions, Sir Auberon Herbert. Bloody Sweat, J. H. Pooley, M. D. Protective Mimicry in Marine Life, Dr. W. Breitenbach. The Chemistry of Cookery, W. Mattieu Williams. Advantages of Limited Museums, Oscar W. Collet. The Architecture of Town-Houses, Robert W. Edis, F. S. A. Mountain Observatories. Sketch of Sir Henry Roscoe (with Portr it). Editor's Table: Harrison and Spencer on Religion; A Healthy Materialism; Politics and Science. Literary Notices. Popular Miscellany. Notes.